A TECHNOLOGICAL FORECAST FOR GALLIUM ARSENIDE LASERS

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THESIS

A TECHNOLOGICAL FORECAST FOR
GALLIUM ARSENIDE LASERS

by

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A technological forecast for GaAs injection lasers operating at room temperature is made. It indicates significant technological progress followed by widespread use for optical waveguide communications in the early 1980's. Extrapolated values for power, efficiency, lifetime, threshold current, and cost per watt are tabulated for the years 1976 and 1980. Two trend extrapolation techniques based on the different assumptions that technological progress advances exponentially with time and that technological

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20. progress advances exponentially with cumulative production are compared. The technological progress function which uses patent output as a measure of cumulative production is determined to be the best measure in the case of the injection laser.

A Technological Forecast

for

Gallium Arsenide Lasers

by

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ABSTRACT

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I. INTRODUCTION AND FORECAST

A. OBJECTIVE

The objective of this undertaking is to use variations of two different trend extrapolation techniques to forecast for 1980, the state of technological development and the values of characteristic parameters for the room temperature gallium arsenide p-n junction injection laser.[1]

B. FORECAST

Further improvement of room temperature injection laser characteristic parameters is not required for widespread usage of injection lasers by 1980 in military devices such as bomb fuzes, range finders and covert illuminators. Due to the unpredictability of down times resulting from atmospheric conditions there will be only limited military use, and virtually no commercial, use of communications systems using the atmosphere as a propagating medium.

The primary developmental emphasis through 1980 will be directed towards employment of injection lasers in optical waveguide communications systems. The previous barrier of room temperature cw operation, which has been overcome, is now replaced by a new requirement that the diode operating lifetime be on the order of 10^5 hours (approximately 12 years).

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[1] It is common practice to simply shorten the description to injection laser, semiconductor laser, or diode laser and since this can be done without too much confusion it will be done hereafter.

It is expected that this requirement will be demonstrated in low power laboratory devices by 1978. The power output of single mode cw devices can not be expected to increase much beyond the limit of 10-15 mw per mode which appears to be a common limit for all semiconductors. If lasers meeting the requirements for optical communications systems can be produced commercially using mass production techniques low power output will not be restrictive since the use of numerous signal amplifiers will be economically feasible. Thus, after the demonstration of long lifetime diodes, the remaining goal will be to develop fabrication processes to the point where high performance diodes can be produced consistantly. It is expected that when this is accomplished, sometime in the early 1980's, the use of injection lasers for communications will become widespread. It is not expected that there will be a significant increase in usage in any other application area except data processing. As the use of the injection laser for communications becomes widespread the market growth, which has been linear, will change to exponential. Exponential market growth and increased cumulative production imply that the technical approach represented by the GaAs laser will be replaced by another approach chosen to maximize radiance. This forecast is supported by data presented in Section III from which forecasts were made for specific laser parameters for the years 1976 and 1980.

C. FRAMEWORK

The art of forecasting was basically intuitive in nature until the early 1950's when pressure began to mount for

better technological forecasts [Lovewell and Bruce 1962]. The evolution of the science of technological forecasting over the past twenty years has produced numerous definitions and variations of methodology. Lanford defines technological forecasting as the "prediction or determination of the feasible or desireable characteristics of performance parameters in future technologies" [Lanford 1972]. Lanford also classifies the various methodologies into two broad categories: exploratory and normative.

Exploratory technological forecasting usually involves trend extrapolation and its objective is to forecast future parameters based on the history of development and the present state of the art.

Normative forecasting is essentially the inverse of exploratory forecasting. In the normative approach a future objective is established and the forecaster works backward through time to determine the nature and timing of improvements necessary to meet the objective.

The trend extrapolation technique for technological forecasting, which is the only one considered in this paper, is one of nine basic variations of the exploratory approach as listed and defined by Lanford. Table I shows that trend extrapolation can be subdivided into further variations of methodology. This paper will limit its discussion to categories 7.2, 7.b, 7.c.2, 7.c.4, and 7.c.10.

Before a technological forecast can be made it is necessary to establish some framework for considering the process of technological innovation and for developing the

TABLE I. Classification of Exploratory Technological Forecasting Methodologies. [Lanford 1972]

Exploratory Forecasting Methodologies

1. Individual of "Genius"

2. Polls

3. Panels/Committees

4. Delphi
   Digitometer Exercise

5. Scenarios

6. Monitering

7. Trend Extrapolation
   a. Straight Line or Fitted Curve Extrapolation
   b. Envelope Curve Extrapolation
   c. Trend Correlation
      (1.) Substitution Analysis
      (2.) Biological Growth (Pearl's Law)
      (3.) Hartman Model
      (4.) Economic Growth (Gompentz' Law)
      (5.) Cellular Analogy (Lenz)
      (6.) Bisexual Reproduction Analogy (Lenz)
      (7.) Acceleration Analogy
      (8.) Seamans Model
      (9.) Abt Model
      (10.) Fusfeld Model
   d. Precursive Indicators

8. Leontief Model

9. Lenz Learning Law

forecast. The process of technological innovation is defined by Bright as a "phrase intended to embrace those activities by which technical knowledge is translated into a physical reality and becomes used on a scale having substantial societal impact" [Bright 1973]. Bright goes further by identifying "those activities" with eight stages or milestones (Table II) that can be used to measure the rate of translation. He also points out that the forecaster must be rigorous in defining the stages to be considered and that the forecast must be definite in relation to these stages. The technological forecast will be concerned primarily with the level of injection laser development necessary to move from stage 6 to stages 7 and 8.

For the purpose of developing the technological forecast a three phase approach based on a proposal by Lovewell and Bruce [Lovewell and Bruce 1962] has been adopted (Table III). Within each phase there are some basic requirements that should be fulfilled prior to making the forecast for that phase.

Three basic requirements are included in the preliminary survey of phase I. The first is to trace the technological development in order to determine the history of the technology, its most recent advances, the current emphasis of research and application and who is involved. A second requirement is to identify what the favorable or unfavorable characteristics or parameters are in order to determine significant problems yet to be solved. The determination of the underlying forces that affect the technological development

TABLE II. Stages in the Process of Technological Innovation. [Bright 1973]

Stage	Identified By	Comment
1	Scientific suggestion, discovery, recognition of need or opportunity	Latter source seems to be origin of majority of contemporary innovations
2	Proposal of theory or design concept	Implying crystalization of theory or design concept that is ultimately successful; usually culmination of much trial and error
3	Laboratory verification of theory or design concept	Demonstration or existence or operational validity of concepts suggested in previous stage; may be difficult for manager to assess since thing demonstrated usually is phenomenon rather than application
4	Laboratory demonstration of application	Principle is embodied in laboratory "bread board" model of device (or sample material or its process equivalent) showing theory of Stage 2 reduced to (hopefully) useful form
5	Full scale of field trial	Concept has moved from laboratory bench into its first trial on large scale; succession of prototypes follows, leading eventually to saleable model

TABLE II. (Continued)

6	Commercial introduction or first operational use	First sale of an operational system; may be deliberate or unconscious premature application of previous stage and so be replete with debugging problems and subsequent changes in technology
7	Widespread adoption as indicated by substantial profits, common usage, and significant impact	Admittedly, not sharply defined; individual firm might choose to classify as recovering its R&D investment through profits on sale of innovation or simply achievement of profitability; nationally, one might define this as given percent displacement, or as given percent of adoptors
8	Proliferation	Technical device is applied to other uses; or principle is adapted to different purposes; this state may begin much earlier

TABLE III. Steps in Predicting Technological Change. [Lovewell and Bruce 1962]

Select Technology for Study

Phase I

- Preliminary survey
  - Trace developmental history
  - Determine favorable and unfavorable characteristics
  - Determine forces driving development
- Forecast potential level of achievement

Phase II

- Consider potential applications
- Consider competition from rival technologies
- Forecast overall outlook for technology and its rate of development

Phase III

- Investigate direct consequences and timing
- Investigate indirect consequences and timing
- Forecast effect on other technologies, etc.
- Forecast effect on business and other operations

is the third requirement and it completes the preliminary survey. The background data provided by the preliminary survey is evaluated using technological forecasting techniques and an estimate is made concerning the potential level of achievement of the technological development in a given time span.

The result of phase II should be an overall outlook for technological change stated in terms such as market size or anticipated production. A basic requirement is to determine applications where the technological development can be employed and then to consider rival technologies in terms of performance characteristics, initial costs, operating costs, materials availability, etc. The comparison with alternate technologies can be quite difficult because the multitude of peripheral factors which can affect the future of each technology is compounded. Further difficulty is introduced when the alternate technologies are also in developmental stages. Fortunately the problem is simplified somewhat by the fact that most emerging technologies are, at least in some aspects, complementary with other technologies and therefore have some area where there is essentially no competition.

Phase III involves investigating direct and indirect effects of the technology on other areas in terms of competition, business and market patterns. For example the development of a long life diode laser will have a direct effect on the market for optical fibers and this will have indirect effects on the suppliers to the manufacturers of the optical fibers.

The objectives of this thesis coincide with those of phases I and II. In order to evaluate the various techniques of trend extrapolation the forecast is developed primarily in terms of phase I since the results of phases II and III are much harder to quantify. Sufficient information is included in the preliminary survey for phase I to allow a phase II forecast to be made.

D. METHODOLOGY

The research in support of this thesis was primarily conducted in the two relatively different and separate areas of the procedures for technological forecasting and the preliminary survey for the semiconductor laser.

The greatest percentage of the time spent in data collection for the preliminary survey was devoted to a search of the patent literature. A comprehensive search of several patent classifications associated with lasers was conducted and the patent titles resulting were organized in chronological order according to the date on which the patents were filed (Appendix A). The patents were inspected for information germaine to the preliminary survey and this information was correlated with information contained in books and periodicals.

II. PRELIMINARY SURVEY

A. LASER CLASSIFICATION

There is no universal method for the classification of lasers. Most classification systems are based on the nature of the lasing media and the method employed to obtain stimulated emission from the media, however other categories based on physical characteristics of the emitted radiation are used at times. For the present purpose lasers can be considered to fall into three broad categories based on the nature of the lasing media: gas, liquid, or solid state.

One of the two subcategories of solid state lasers is the semiconductor laser in which the emitted radiation results from the recombination of charge carriers. The other subcategory includes lasers in which the lasing medium consists of a crystal lattice with embedded ions capable of stimulated emission as the result of downward transitions from excited states.

The semiconductor laser subcategory can be further divided according to which of four means of obtaining the required population inversion is utilized. The first method of obtaining a population inversion is by optical pumping using intense light of a wavelength appropriate to the bandgap of the semiconductor material employed. This method is similar to that used almost exclusively in ionic solid state lasers. The second method employs the avalanche breakdown which results from impact ionization in a strong electric field

($> 10^5$ volts cm^{-1}). In this case the electric field generates free charge carriers which are in turn accelerated by the field causing further ionization in an avalanche process. The third method, electron beam excitation of the semiconductor, is similar to the avalanche breakdown method in that minority carriers necessary for radiative recombination are generated by the impact of electrons on the semiconductor crystal lattice. The difference is that in electron beam pumping the electron acceleration is external to the semiconductor whereas in avalanche breakdown, it is internal. The fourth method is to inject charge carriers into the semiconductor material through a dielectric layer by quantum mechanical tunneling or through a forward biased junction. There are two ways of creating junctions for carrier injection. The first is simply a metal-semiconductor junction and the second is a junction created by the transition of a semiconductor from a region of p-type doping to n-type doping. If the semiconductor material has the same bandgap on each side of the junction it is called a homojunction whereas if the bandgaps are different it is called a heterojunction. Further classification of solid state, semiconductor, injection, p-n junction lasers requires specification of the semiconducting materials employed and of the laser structure. The various laser structures such as homostructure, heterostructure, mesa and stripe will be considered in the history of laser development.

Table IV is a partial listing of semiconductor compounds in which stimulated emission has been observed. A more

TABLE IV. Semiconductor Compounds in Which Lasing has been Observed. [Pankove 1971 and Morehead 1969]

Wavelength (microns)	Semiconductor/Symbol	Method of Excitation			
		Avalanche	Electron Beam	Injection	Optical
0.33	Zinc Sulfide ZnS		X		X
0.37	Zinc Oxide ZnO		X		
0.49	Cadmium Sulfide CdS		X		X
0.53	Zinc Telluride ZnTe	X	X		
0.55-0.70	Gallium Phosphide GaP			X	
0.61-0.90	Gallium Arsenide Phosphide $GaAs_xP_{1-x}$		X	X	
0.63-0.90	Gallium Aluminum Arsenide $Ga_xAl_{1-x}As$			X	
0.85	Cadmium Telluride CdTe		X	X	
0.83-0.91	Gallium Arsenide GaAs	X	X	X	X
1.55	Gallium Antimonide GaSb		X	X	
3.1	Indium Arsenide InAs		X	X	X
5.4	Indium Antimonide InSb		X	X	X
6.5-16.5	Lead-Tin Telluride $Pb_xSn_{1-x}Te$			X	X

complete list which identifies thirty-eight different compounds and their corresponding references has been compiled [Pankove 1971]. Although the range of possible choices appears large GaAs has the best combination of optical properties and direct bandgap[2] recombination mechanisms. Another factor stimulating interest in GaAs is that the infrared wavelengths associated with these lasers correspond with the wavelengths at which the most available and easily used photodetectors have their peak sensitivity ($\lambda \approx 0.8\mu$). The result has been that the major part of semiconductor laser research effort and commerical development in the United States has involved alloys of GaAs, thus other semiconductor compounds have been excluded from consideration in this paper. It is interesting to note that in the Soviet Union the emphasis has been on silicon carbide which produces wavelengths in the visible portion of the spectrum. Although silicon carbide employs indirect transitions which are less efficient, it has the quite attractive advantage of not requiring cooling [Furlow 1969].

B. INJECTION LASER CHARACTERISTICS

1. Favorable

The developers of the injection laser were quick to point out, first in their patents and then in the literature,

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[2] It is important that the material specified have a direct bandgap so that the recombination process takes place between energy states that have the same momenta at the bandgap. The recombination process in indirect bandgap materials involves the creation of elastic waves (phonons) which cause thermal heating.

the following important characteristics of the diode laser:

a. ease of diode construction,

b. simple construction of laser system,

c. small size,

d. ease of modulation,

e. high efficiency, and

f. tunability.

These favorable characteristics will be discussed in the following paragraphs.

The technology for diode laser fabrication draws heavily upon the established transistor technology whereas many other laser systems involve the development of completely new areas of technology. It was easily envisioned that, as in the case of transistors, mass production would be feasible. Implicit in mass production is the prospect for a drastic reduction in cost.

Compared with the support apparatus required for other laser systems that of the diode laser is extremely simple, even when cooled to cryogenic temperatures. This is primarily due to the fact that systems for pumping most other lasers are not as compact as the pulser for a diode laser. This is particularly true for optically pumped lasers, which require elaborate mirror systems and intense light. Additionally most other laser systems have requirements such as heating in the metal vapor laser, gas supply/exhaust in the gas dynamic laser, liquid flow systems in the liquid laser, etc, which further complicate the laser construction.

The size of the diode laser is at least one order of magnitude smaller than any other laser. This diminutive size makes the injection laser practical for a host of applications not suitable for larger laser systems.

The diode laser permits direct modulation of its input current using AM, FM or pulse position modulation. The diode can also be modulated by incorporating onto the crystal body a piezo-electric transducer so that electric pulses can elastically stress the diode crystal [Hall 1966]. The emitted light from other lasers generally has to be modulated externally to the lasing medium by using a Pockels or Kerr cell.

Possibly the greatest advantage of injection lasers lies in their efficiency. Quantum efficiencies of greater than 50% and power efficiencies of approximately 20 to 30% were initially reported [Hall 1966]. These values were more than ten times that reported for any other laser system. There was some evidence that the ultimate quantum efficiency would approach 100% [Burns 1966]. In a patent filed in February 1963, it was reported that at 4.2^{o}K a diode unit operated at a quantum efficiency of nearly 100%, i.e., that for every electron crossing the junction, one photon is emitted [Zieger 1963].

When the diode laser was introduced, most other laser systems produced an output that was, in general, restricted to a single optical frequency or possibly its harmonics. This had at least two consequences. First systems had to be designed to operate with available frequencies and second

there were gaps in the optical spectrum. The diode laser has the potential of being tuned to a specific frequency and therefore having its utility increased relative to other lasers [Ashkin 1967].

2. Unfavorable

Following closely upon the wave of optimism that came with the introduction of the diode laser was an equally large wave of pessimism when it became obvious that the following unfavorable characteristics were not going to be overcome readily:

a. low average power,

b. short lifetime,

c. temperature dependence of lasing threshold,

d. beam divergence, and

e. multimode operation.

These disadvantages have been the focus of virtually all research and development and even though great improvements have been realized, they are still the characteristics that impose limits on the diode lasers full employment.

Low average power and operation at cryogenic temperatures was the rule when the diode laser was first introduced. Even though room temperature operation has now been achieved in both pulsed and CW modes of operation low average power is still very much a disadvantage. It should be noted however that due to the low average output power and high efficiency most diodes can be pulsed using a small battery power supply. This can be an advantage as it allows packaging of a diode, pulser and battery in a unit that can be held in the palm of a hand.

The lifetime of early diodes was usually less than 100 hours. Not only did diodes fail early but there was a steady degradation of performance throughout their lifetime. The lifetime of diodes has in some cases been increased by more than one order of magnitude but there is still much improvement required in the areas of lifetime and reliability.

Output power and frequency are strongly dependent on the diode temperature. Changes of temperature caused by the driving current or the diodes environment can cause a variation of the output that is unacceptable for many applications. If a certain temperature is exceeded or if the operating temperature drops below a certain temperature without a reduction of the driving current failure can result.

The extremely narrow region of the active lasing portion of the diode, i.e., the junction, causes the emitted light to be subject to significant diffraction effects. The end result is that unless external optics are used to colimate the beam, the beam will diverge at angles of twenty to thirty degrees.

The attainment of single mode operating has been one of the goals of laser structure development. Single mode operation is an important requirement for optical fiber transmission so that there will be no significant material dispersion.

C. FORCES DRIVING DEVELOPMENT

1. Applications

In order to understand the forces driving development it is necessary to consider some present and projected applications for the injection laser. This will be approached by looking at seven general application categories that are usually recognized for all types of lasers. In the discussion of these categories considerations will only be given to those aspects of a given application that are related either to lasers in general or diode lasers.

a. Materials Processing

Materials processing includes such diverse operations as machining, cutting, drilling, scribing, welding, soldering and dynamic balancing. The two prime requirements for satisfactory performance of a laser in this area are small spot size and high power output - both of which are not advantages of the injection laser. Even if the diode laser were to attain a level of performance whereby some materials processing could be accomplished it is doubtful whether it would become a significant area of application, since conventional techniques including microwaves and electron beams are in many cases more competitive.

b. Communications

The field of optical communications is large and extensive work is being done in this area. The primary motivation for exploiting optical communications is the enormous bandwidth available when operating in the region of 10^{13} to 10^{15} Hz. Approximately 10^{9} to 10^{11} channels of

information 10 kHz wide could theoretically be transmitted using one optical beam. This large bandwidth is currently not attainable, however its full realization is not necessary for most applications. The diode laser has many advantages that suit it to optical communications not the least of which is its ease of modulation. Problems involving the coupling of the laser which has a high index of refraction to optical fibers which have a low index have been basically overcome and the only factors currently restricting the use of the diode laser are its limited lifetime and cost.

The development of optical fibers for use as waveguides will open up new applications in at least five new areas [Thiel 1973].

Application	Principal Function
Telephone	Intercity trunks Interoffice trunks Local loops
Broadband networks	CATV Dedicated communications networks
Computer	Dispersed system Intrasystem wiring
Process control and instrumentation	Computer based industrial process control Instrumentation
Military	Internal wiring of weapons systems Tethers for instrument packages attached to weapons/surveillance systems

The use of optical waveguides for telephone transmission represents the largest potential application. A

single mode diode laser that could operate cw at room temperature would be the preferred source for this application. Although the more power that the diode can deliver the better, the critical factors for this application are reliability and lifetime. The diode laser, because of its small size it can be coupled to waveguides more readily than other lasers. Additionally light amplifiers can be inserted in cables without significantly increasing the diameter of the cable. The requirements for the other four areas are similar to those for telephone communications.

The transmission of data including voice communications through the atmosphere using lasers with infrared wavelengths is of particular interest to the military due to its covert nature. The Navy has developed a small optical communication system employing injection lasers for use between ships when refueling [Schlisser 1970]. The diode laser is the only type that is really suitable for this system due to its compactness, and low power requirements. There are problems with ambient temperature variations which limit the communications effectiveness. Temperature variations can change the pulse width by as much as 10% thus placing limitations on the modulation techniques employed. For the system described by Schlisser, if the temperature drops ten degrees and there is not a reduction of laser current the diode will fail. Power and beam divergence are critical factors in atmospheric transmission.

c. Data Processing

A digital computer as generally conceived,

consists of four basic functional elements: input, memory, central processor, and output. There is a potential for application of the laser, and particularly the diode laser, in all of these four data processing areas. The scope of the term data processing must not be limited to include only the digital devices which dominate the field today but also must include analog systems such as those falling in the category of optical computing.

The practical realization of an injection laser with a reliability and lifetime comparable to current electronic digital devices and with little degradation of performance during its lifetime will open wide the prospects for extensive use of ultra-high speed optical digital devices. The ultra-high speed capability is limited by the recombination time in the semiconductor material which is on the order of 10^{-9} secs. This is short compared to the time for storage of a bit of binary information in current electronic computers which is of the order of 10^{-6} secs.

The patent literature reveals at least four different approaches to performing digital operations using injection laser devices. The first approach uses two coupled diodes with one acting as a laser and the other as an optical amplifier [Fowler 1967]. A variation of this uses a second diode as an optical shutter [Lasher 1969]. In essence the output of both of these is an on/off signal resulting from an AND operation. The second approach involves the use of an injection laser which radiates coherent light having two planes of polarization different from each other [Kitsutare

1970]. By appropriate inputs binary operations can be performed using the two polarization planes as binary outputs. The third method employs two cavity resonators, each with a saturable absorber, which share a common active lasing medium [Kosonocky 1969]. In the fourth approach, which is applicable to reading stored data, plane polarized light from an injection laser is directed upon a ferroelectric medium that exerts a polarization rotational effect on the light. The rotation of the light that occurs during reflection from or transmission through the medium determines the direction or state of charge of the region addressed. In a variation of this approach the rotation of a polarized light beam is a function of the thickness of the addressed portion [Weider 1973].

All of these approaches have the potential of being incorporated into micro-miniaturized systems through the techniques of integrated optics. Using integrated optics and mass production, optical digital computers with capacities greater than current electronic versions could be envisioned.

The primary advantages offered by optical analog computers based on coherent (or Fourier) optics and holography are the capabilities of parallel processing and mass storage of information. There are currently at least three fields that have assumed major importance on the basis of optical computing principle: optical image deblurring, coherent side looking radar and correlative pattern recognition [Stroke 1972]. The prime consideration when choosing a light

source for any of these applications is the coherence of the beam. This is particularly important for holographic operations.

The injection laser, which lacks sufficient coherence for producing quality holograms (as compared to other lasers), can be employed to read out holographic information in real time. If the coherence of the injection laser would become comparable to that of other lasers its advantages of efficiency, low cost, compactness and reliability[3] would make it very competitive in this area.

d. Biomedicine

The area of biomedicine includes photocoagulation for opthalmology, experimental laser surgery and biomedical research. Important parameters are wavelength, pulsewidth and size. The wavelength is important because it determines the spot size to which the beam may be focussed. In eye surgery, it is particularly important because the beam must be visible so that the optics of the eye will allow focussing on the proper spot of the retina. Short pulse width is important to protect against thermal diffusion and wander effects caused by motion of the patient. Compactness is important in surgery where manual dexterity is necessary. The diode laser will not be considered for this field until its output can be extended into the visible range at sufficiently high powers.

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[3] Reliability here is in reference to other lasers not to electronic components as previously discussed.

e. Measurement

The area of measurement includes interferomety, spectroscopy, rangefinders and alignment. Interferomety using coherent light can be used for numerous applications such as detection of vibration and measurement of deformations. A more precise method, but also a more complex one, is hologram interferomety. This is the major application of holography and it has proven quite competitive with such standard techniques as x-ray and ultrasonic analysis for nondestructive testing of materials [Leith 1972]. Again the coherence properties of the injection laser limit it from widespread application in this area.

Two forms of spectroscopy may be considered as suitable for laser application. The first would be emission spectroscopy where a laser with sufficient power is used to excite the substance to be observed instead of a flame or an electric arc. The second would be absorption or Raman spectroscopy. In this case analysis can be conducted without destroying the specimen by observing the change in the wavelength of the reradiated light from the specimen. The critical parameters for absorption spectroscopy are tunability and a narrow bandwidth. Semiconductor lasers have a narrow tuning range but this can be overcome by selecting a variety of diode compositions. Semiconductor lasers have an advantage over dye lasers and parametric oscillators pumped by Argon or Nd-yag lasers since they are easier to tune to a narrow bandwidth. Any increase in the range of tunability of semiconductor lasers will make them more competitive.

Laser rangefinders can be used for such varied applications as aircraft altimeters, bomb fuzes, and mobility aids for the blind. For the mobility aids where the small size of the laser allows installation in the tip of a cane or the frame of eyeglasses, there is virtually no competition for the diode laser. The size parameter both of the laser and its auxiliary equipment, it also probably one of the strongest attractions for military development of the laser. Besides the bomb fuses the military has already been involved in various portable rangefinding devices, some of which can be mounted on small arms. Parameters that currently limit rangefinder performance are power and in some cases beam divergence.

The category of alignment includes surveying, guidance of construction equipment, and positioning of precision machinery and parts. There are two particularly desireable features that a laser should have for application in this area. These features, neither of which is possessed by the GaAs diode laser, are that the laser beam be visible and that the shape of the beam should be uniformly cylindrical.

f. Surveillance

In the area of surveillance, which includes illumination and intrusion alarms, the attractive characteristic of the galliun arsenide injection laser is the fact that it produces invisible, or covert, radiation. For this reason much of the development has been associated with the military. A typical illuminator pulses a diode array to produce a 1 kHz beam with an average power of up to 30 watts [Campbell 1972].

The illuminated scene can be viewed on an image converter tube which is sometimes gated so that it will only respond to radiation reflected from objects at a specified distance from the viewer. Gated viewing is particularly useful in seeing through fog and smoke. The diode lasers compact size, rugged construction and low power supply requirements have established it as the primary laser in this area.

The intrusion alarm area is one that will be dominated by the injection laser. Currently light emitting diode's (LED's) are finding wide application but as the cost goes down and lifetime and reliability of diode lasers goes up, their use will become more and more widespread. There are numerous companies marketing various types of intrusion alarms for both military and civilian use. The pulsed operation of the diode laser at room temperature allows coding of the beam so that the number of false alarms from natural occurances such as falling leaves can be minimized [Campbell 1972].

g. Miscellaneous

Two miscellaneous applications include using the diode laser as an optical pump source for other lasers and as a laser gyro. The use of injection lasers to pump solid state ionic lasers instead of the conventional flash lamps offers two advantages. First the system will be more rugged since it will be completely solid state and second the diode laser which can be easily modulated expands the potential for use of the solid state ionic laser, such as the Nd-YAG laser, in communications. At least two patents have been issued for

lasers with diode pumping. Important considerations include matching the wavelength of diode emission to that of absorption in the laser rod, removal of diode heat and reducing losses at the diode-laser rod interface.

A curved junction laser device has been developed that has potential application for use in highly sensitive gyroscopes such as those used in space vehicles where the small size may prove advantageous [D'Asaro 1971].

2. Centers of Development

Consideration of the various laser applications has shown that the most significant advantages that would result from feasible development of the injection laser are in the area of communications and data processing. That the forces driving development are provided primarily by those who hope to profit from development in their respective areas, is supported by the data in Figure 1 and Table V. The obvious conclusion is that the primary force driving development is provided by those working to develop the laser for communication purposes.

3. Environmental Influences

The forces driving development are what move the process of technological innovation through its eight stages. This process can not be isolated from the important influences of the political, social, ecological, economic, and technical environments. These influences can actually control the economic viability of existing technologies and the emergence of new technologies [Bright 1973].

TABLE V. Patent Assignees, Number of Patents Held, and Percent of Total Number of Semiconductor Patents.

Patent Assignee	Number of Patents Held	Percent of Total
Largest Patent Holders	46	37
Bell Telephone Labs	29	23
IBM	17	14
Electronics Industry (U.S.)	35	28
RCA	15	12
General Electric	14	11
Texas Instruments	5	4
Raytheon	1	1
Electronic Industry (Foreign)	20	16
Private Individuals	6	5
MIT University	5	4
U.S. Government	4	3
Aviation Industry	3	2
Boeing	2	2
McDonnel Douglas	1	1
Miscellaneous	6	5

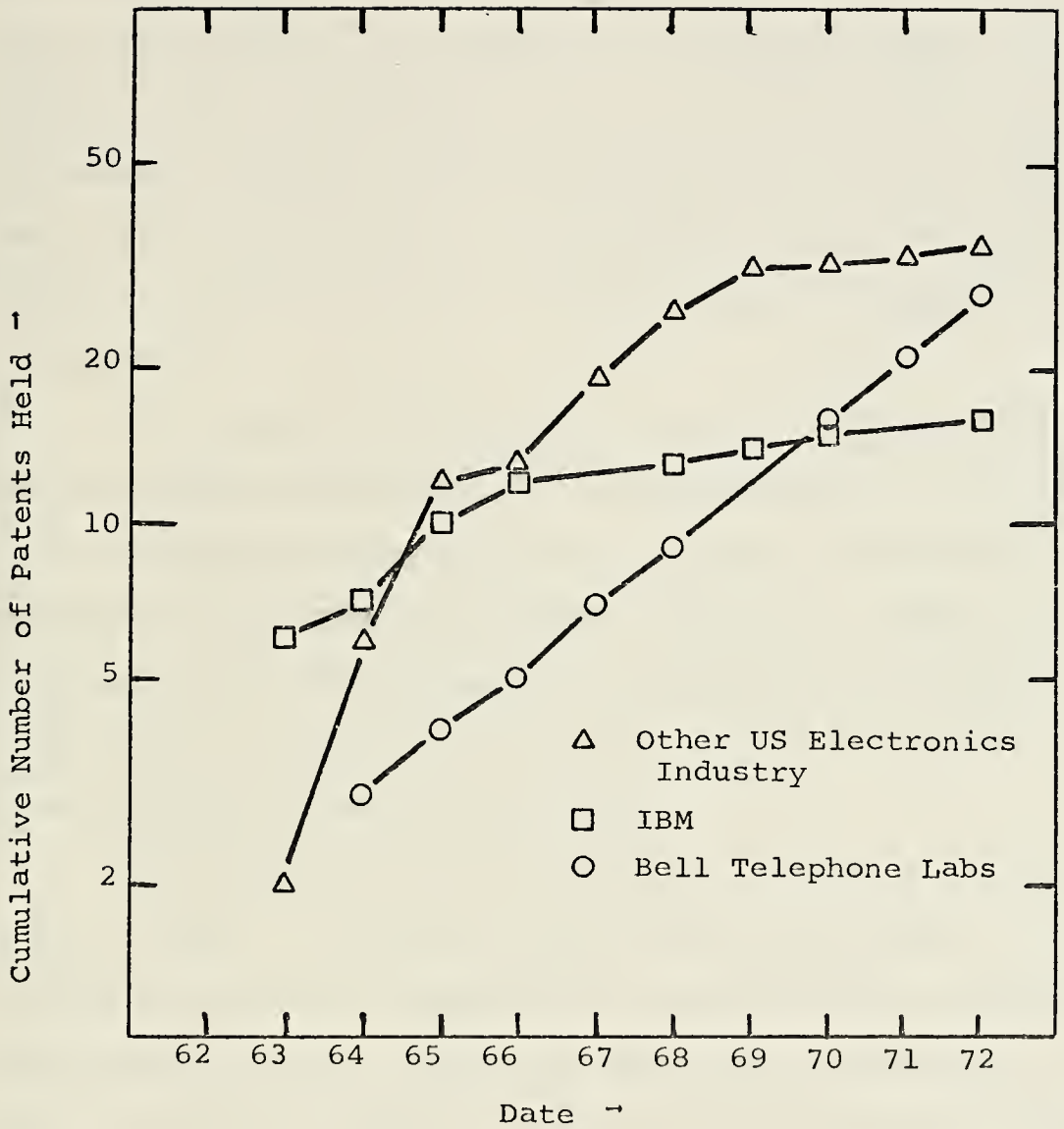

Figure 1. The Cumulative Number Patents Held by Leading Centers of Injection Laser Development.

The political environment includes the effects of legislation and government funding for research. The passage of excessively restrictive health or safety legislation regrading laser radiation could drastically affect the widespread employment of injection lasers in several of the applications areas. The extent of government support for injection laser development was not determined, however all of the major research and manufacturing centers for diode lasers have been involved in development work under government contract and there is some indication that this support may be extensive.

The effects of the social and ecological environment are not easily determined for the injection laser. Generally their influences are more likely to manifest themselves in the political or economic environment. Refusal to adopt new technology due to an incomplete understanding or simply a resistance to change is one way the social environment could affect injection laser development.

The effects of the economic environment should be fairly obvious. A strong economy with an optimistic market outlook will provide stimulus for innovation and continued technological growth. Major market upsets, recessions, wars, etc, can have the opposite effect and even bring the process of technological development to a halt.

The technical environment is determined by the level of scientific achievement or knowledge of the physical processes for the area of interest which has been gained through academic research and the work of R and D establishments.

This environment influencesinnovation activity through the amount of information or education available [Haeffner 1973].

D. HISTORY OF DEVELOPMENT

1. Stages of Development

The following chronology which has been assembled from historical surveys by Lax [Lax 1965] and Hilsum [Hilsum 1969] relates some events in the development of the semiconductor laser to the first three stages in the process of technological innovation as shown in Table II.

Stage 1: Identified by scientific suggestion, discovery, recognition of need or opportunity.

1954 - Development of ammonia maser and speculation about solid state lasers.

- It was known that semiconductors emit in visible and IR regions.

- John Von Neuman proposed electrically pumped device much like present junction laser, however suggestion was ahead of the state of the art.

1955 - Direct gap radiative recombination was shown to be a dominant process in InSb at low temperature.

- Braunstein made first observations of radiation emission from GaAs.

1957 - Aigrain suggested point-contact device for excitation of semiconductors.

1958 - Aigrain reported no success in attempts to optically or electrically pump semiconductors such as silicon and germanium.

1959 - First Quantum Electronics Conference.

- Possibility of coherent radiation from semiconductors examined by Basov.

1960 - Ruby Laser

1961 - Second Quantum Electronic Conference. Basov suggested electron beam excitation.

- Gas Laser.

- Benard and Durafourg showed theoretically the necessary criterion for inverting the population in a semiconductor.

Stage 2: Proposal of theory or design concept.

- Basov and others deduced that a forward biased p-n junction could be used to obtain an inverted population.

Stage 3: Laboratory verification of theory or design concept.

Jan 1962 - Narrowing of linewidth of radiation emitted from GaAs diodes reported by Nasledov along with suggestions that this might be a sign of stimulated emission.

Jan 1962 - Keyes and Quist reported internal quantum efficiencies of 85%.

Oct 1962 - Patents filed by General Electric and IBM for diode lasers.

The entry into stage 4 which is identified by the laboratory demonstration of application occurred simultaneously with the development of the first laser diodes. This is because the demonstration of the diode's capability to be modulated had been established prior to October 1962 by using diodes that emitted incoherent radiation. During the period of 1963 to 1965 there were many laboratory demonstrations of application as can be seen from the semiconductor patents filed during this period. The entry into stage 5 is definitely not clear because also during this period numerous prototype communications systems were reported.

The injection laser effectively entered its current stage (stage 6) during 1965 since it was during this period

that lasers, other than prototypes, became commercially available. The date of 1965 for entry into stage 6 could easily be challenged, however there have been a sufficient number of commercial devices in use since 1969 that there can be little doubt that stage 6 is actually the current stage. This is confirmed by the fact that stage 7, which is identified by widespread adoption, common usage and significant impact has definitely not been entered.

2. Laser Devices

The development of the gallium arsenide laser is primarily discussed in terms of laser structures but consideration is also given to the processes involved in fabricating the diode, particularly the method by which the junction plane is formed. The recognition of the requirements for higher quality GaAs and better control of junction formation and doping gradients has served as the stimulus which drives the process of technological innovation in the area of semiconductor processing. The advancement of injection laser technology is tied to the development of semiconductor processing techniques and the realization of new structures has generally awaited the development of the processing technology to the point where the new structures could actually be fabricated. For this reason the development of laser structures can be considered to be a measure of the development in the processing technology. Since the technology of junction formation can also be considered a precurser to improved structures a brief survey of the basic techniques is appropriate before considering the development of the two classes of laser structures: homostructures and heterostructures.

a. Junction Formation

Diffusion, vapor phase epitaxy (VPE) and liquid phase epitaxy (LPE) are the three basic methods of junction formations used in diode lasers. The first patent filed for a semiconductor laser [Burns and others 1966] cited both diffusion and vapor phase epitaxy as methods for junction formation. The process of GaAs liquid phase epitaxy was introduced by Nelson in 1963 [Nelson 1963].

Most of the early lasers were fabricated using the diffusion process to form a single p-n junction. The process of diffusing an acceptor impurity into n-type material is the most successful method of forming p-n junctions by diffusion. Typically zinc is diffused into a wafer (400 - 500 μ thick) of tellarium doped GaAs which has been sliced from a monocrystalline ingot. Once the p-n junction is formed the wafer is cleaved into thin bars and then sawed into laser chips. The process is complicated by the fact that arsenic has a high disassociation vapor pressure at the temperature of 850^{o}C which is required for diffusion. For this reason the process has to be carried out in sealed containers.

Two important criteria for injection lasers are that the junction be flat and that the proper doping profile exists. The process of depositing epitaxial layers produces junctions that satisfy both of these criteria much better than those produced by diffusion processes. Another significant advantage of both VPE and LPE is that layers with high doping levels or different bandgaps can be deposited.

The VPE process offers excellent control over the orientation, thickness, crystalline perfection, and doping levels of epitaxial layers. It is also possible to grow in a single process a complete p-n junction [Rowland 1969]. Despite these advantages VPE has not been extensively used in GaAs construction. Basically the VPE process consists of heating GaAs in a halide or water vapor atmosphere in order to form a vapor that can be transported to a cooler region for redepositing. Two equations that are typical for these processes are

$$4\ GaAs_{(s)} + 2\ GaI_{3(v)} \rightleftharpoons 6\ GaI_{(v)} + As_{4(v)}$$

and $$2\ GaAs_{(s)} + H_2O_{(v)} \rightleftharpoons Ga_2O_{(v)} + As_{2(v)} + H_{2(v)}$$

The LPE process developed by Nelson is characterized by the use of a tipping furnace. Initially a substrate wafer is positioned on one end of a graphite boat and a melt at the other. The melt consists of the material to be epitaxially grown, a dopant, and gallium which acts as a solvent. At about 900°C the furnace is tipped to allow the melt to flow over the substrate. The most important feature of the LPE process reported by Nelson is that the p-n junction is perfectly planar and oriented perpendicular to the (110) cleavage planes. This feature is a result of the fact that before epitaxial growth begins the substrate surface is dissolved and a solution front is formed which coincides with the (100) crystal plane. Another feature of the LPE process is that defects on the substrate surface are removed during the dissolution of the surface layer [Nelson 1963].

In 1970 Hayashi and others reported a method for growing multilayer structures by LPE [Hayashi and others 1970]. In this method a sliding holder with wells for four different solutions could be sequentially positioned over a substrate wafer for epitaxial growth of layers on the substrate.

b. Homostructures

The homostructure laser which employs a single semiconductor material was developed by research teams at IBM, General Electric and MIT's Lincoln Laboratory. The announcement of successful operation of a laser diode by both IBM and General Electric came simultaneously on 1 November 1962 [Ubell 1962]. The patent claims for these diodes were filed by IBM on 15 October 1962 [Burns and others 1966] and by General Electric on 24 October 1962 [Hall 1966]. MIT did not file claims until 7 February 1963 [Zieger 1966].

The patents issued to each of these three teams show at least two different structural concepts. The IBM patent is for a device employing a Fabry-Perot type structure with the light being reflected by surfaces parallel to the plane of the p-n junction as shown in Figure 2. The General Electric and MIT devices show a Fabry-Perot device with the light being reflected between surfaces normal to the plane of the p-n junction as also shown in Figure 2. The General Electric design has proven to be the more efficient because the light travelling between the reflecting surfaces remains predominately in the high gain region of the junction plane

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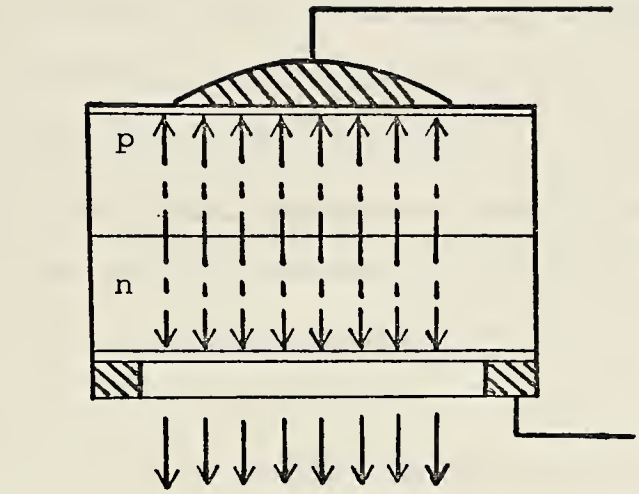
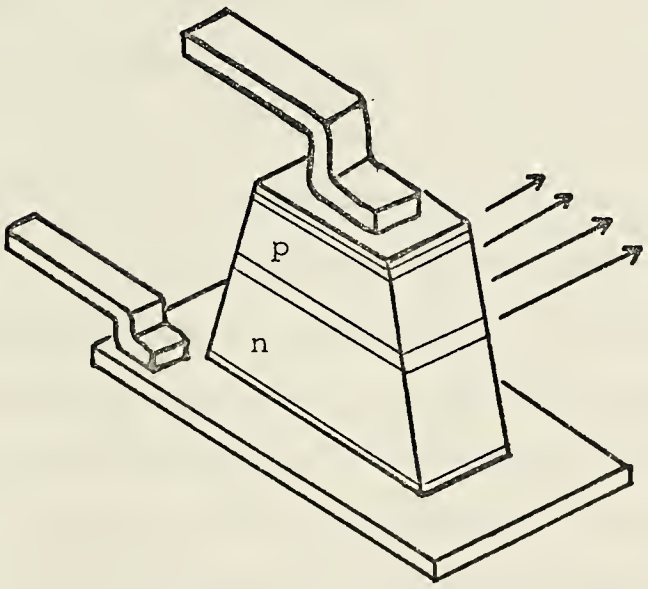


IBM Device



General Electric Device

Figure 2. Comparison of Laser Structure Used by IBM and General Electric in their First Patents [Dumke 1966; Hall 1966].

rather than in the adjacent n and p regions where it is subject to losses.

The high gain region of the junction plane is actually a high index of refraction layer about 1μ thick in which the radiative recombination takes place on the p side of the junction. This active layer can act as a waveguide and therefore reduce the amount of radiation lost to the surrounding n and p regions. Increasing the thickness of the active region decreases the emitted beam spread but increases the number of transverse modes propagating. If the active region is too thin it will not act as a waveguide and radiation will be diffracted into the surrounding n and p regions.

The concept of combining the diffusion process with VPE to produce multilayered diodes was patented by Diemer in March 1963 [Diemer 1969]. By using layers of different index of refraction Diemer was able to increase waveguiding effects and containment of the optical beam.

Three layer devices constructed for the purposes of investigating the processes of spontaneous and stimulated emission were reported by Pilkuhn and Rupprecht in 1966 [Pilkuhn and Rupprecht 1966]. These structures consisted of an n-type, p-type, or intrinsic central layer with an n^+ layer on one side and p^+ layer diffused into the other. All of these three layer structures had a smaller vertical beam spread then conventional Zn-diffused lasers however the $p^+ - n - n^+$ is the only structure that appears to be used to any extent.

The power output of a laser diode can be actually increased by reducing the number of transverse modes that propagate, or effectively increased by designing the laser structure so that the radiation is only emitted from one face. Most of the laser structures designed for increased power have been tailored to reduce the amount of power drawn away from the desired longitudinal modes by transverse modes propagating parallel to the junction plane. The transverse modes propagating normal to the junction plane are controlled by the thickness of the active region.

Increasing the power output of the basic Fabry-Perot structure of Figure 3 requires that the diode width (W) be increased. As the width is increase the gain in the transverse direction increases thus making conditions more favorable for the propagation of transverse modes. Although the formation of transverse modes is supressed by rough side faces which result from sawing or etching small (110) plane facets are still present that allow the build up of transverse modes when gain is sufficient. For a diode with a length of about 10 mils the increase in power output is negligible at widths greater than the length [Goodwin 1968]. The basic Fabry-Perot structure can be improved in several ways. A patent filed in February 1964 by Hall describes a laser with a curved junction used to suppress unwanted transverse modes [Hall 1967b]. In this device the junction extends linearly between two parallel reflecting surfaces allowing longitudinal standing waves to form as the primary mode of oscillation. The junction is curved in the lateral direction

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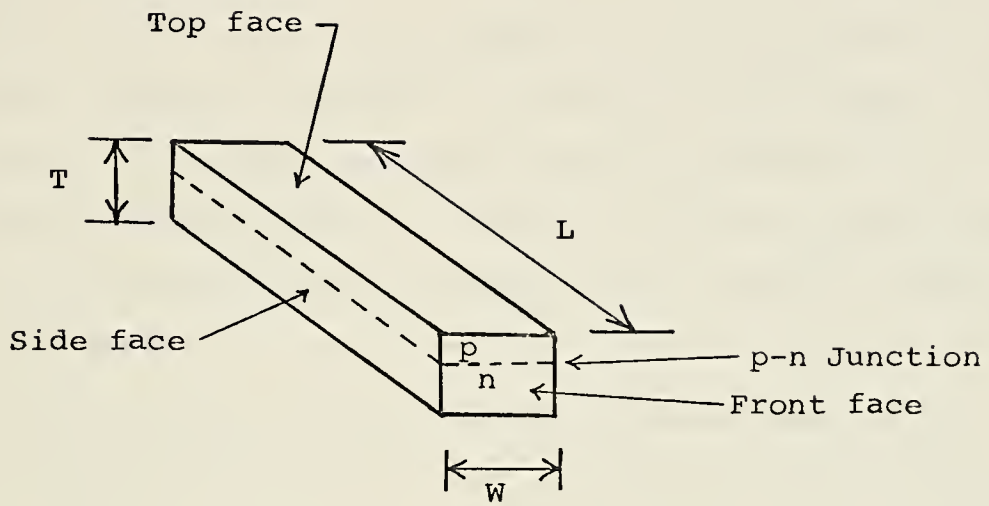

Figure 3. Geometry of the Basic Fabry-Perot Homostructure Laser.

so that radiation propagating in transverse modes passes out of the junction region and into the semiconductor crystal where it is readily absorbed.

The basic Fabry-Perot structure can also be improved by removing the side section of p-type material above the p-n junction plane as shown in Figure 4. This mesa structure effectively suppresses transverse modes in the lossy no gain sections of the p-n junction. Laser gain is absent in the wings because electrical contact is made only to the mesa surface and to the opposing n-region surface, thus current flow is substantially absent in the wings. The advantages of increased power with reduced threshold are supported by data presented by Nelson in his patent which was filed on 27 March 1968 [Nelson 1968] and by Goodwin [Goodwin 1968].

Most laser diodes use the cleaved faces of the crystal as reflecting surfaces for the resonant cavity thus allowing coherent radiation to be emitted from both faces. For many applications the light from only one face can be used thus half of the emitted radiation is wasted. For these applications the effective power can be increased by designing the diode so that it emitts from only one face. This can be done by silvering one face so that it is totally reflecting or by using structures with reflecting surfaces that are perpendicular to each other. Structures designed to emit coherent radiation in unique spatial patterns were developed at the General Electric Research Laboratories by Garfinkel, Engeler and Locke [Garfinkel, Engeler and Locke 1964]. These

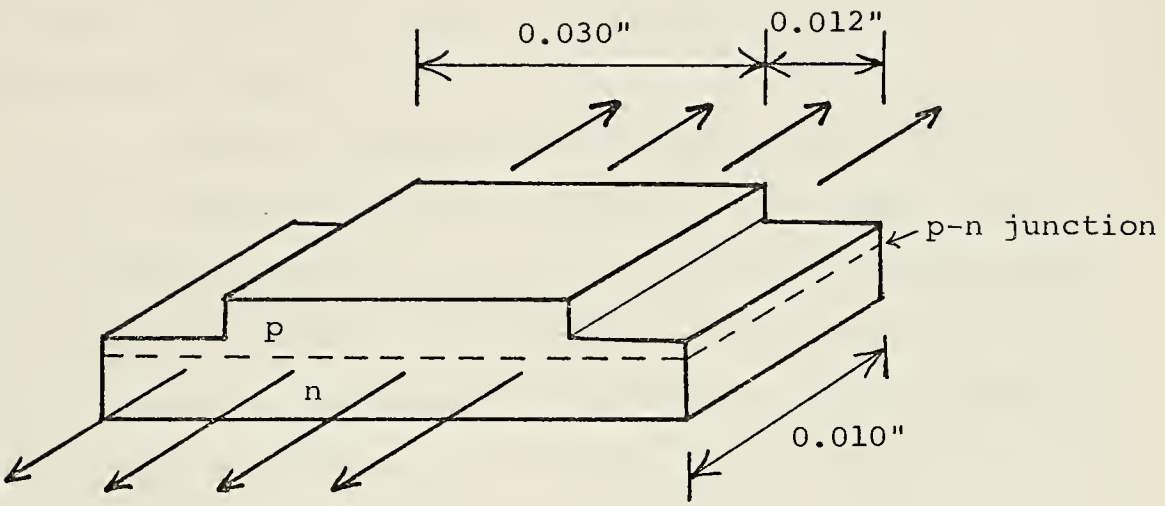

Figure 4. Geometry of the Mesa (or Wing) Homostructure Diode [Goodwin 1968].

structures and their respective spatial output patterns are shown in Figure 5. The three triangular lasers displayed two spatially distinct resonant mode patterns and one that was a combination of the two. The fourth laser oscillated in only the unidirectional mode so that all of the output appears in one beam. A side benefit of this structure is that the orientation of the polished face is not critical. This type structure was combined with an integral heat sink by Garfinkel and Engeler in one embodiment of a patent which they filed for a high power semiconductor laser on 18 April 1966 [Garfinkel and Engeler 1967].

Improved thermal properties and transverse mode control for devices intended to operate at low power levels can be obtained by using a narrow metallic stripe contact on the p side of the laser diode (Figure 6). If the resistance of the p region is sufficient to limit transverse spreading of the current when operating at threshold or higher the active region of the junction will be confined to a narrow region under the stripe contact. The narrow active region allows heat to be conducted away more easily and eliminates transverse modes as evidenced by the improved cw operation and Gaussian radiation pattern observed by Dyment and D'Asaro, [Dyment and D'Asaro 1967].

c. Heterostructures

The dependence of the realization of a laser structure upon the development of junction fabrication techniques is nowhere more obvious than in the case of the heterostructure lasers. The concept of a heterojunction appeared

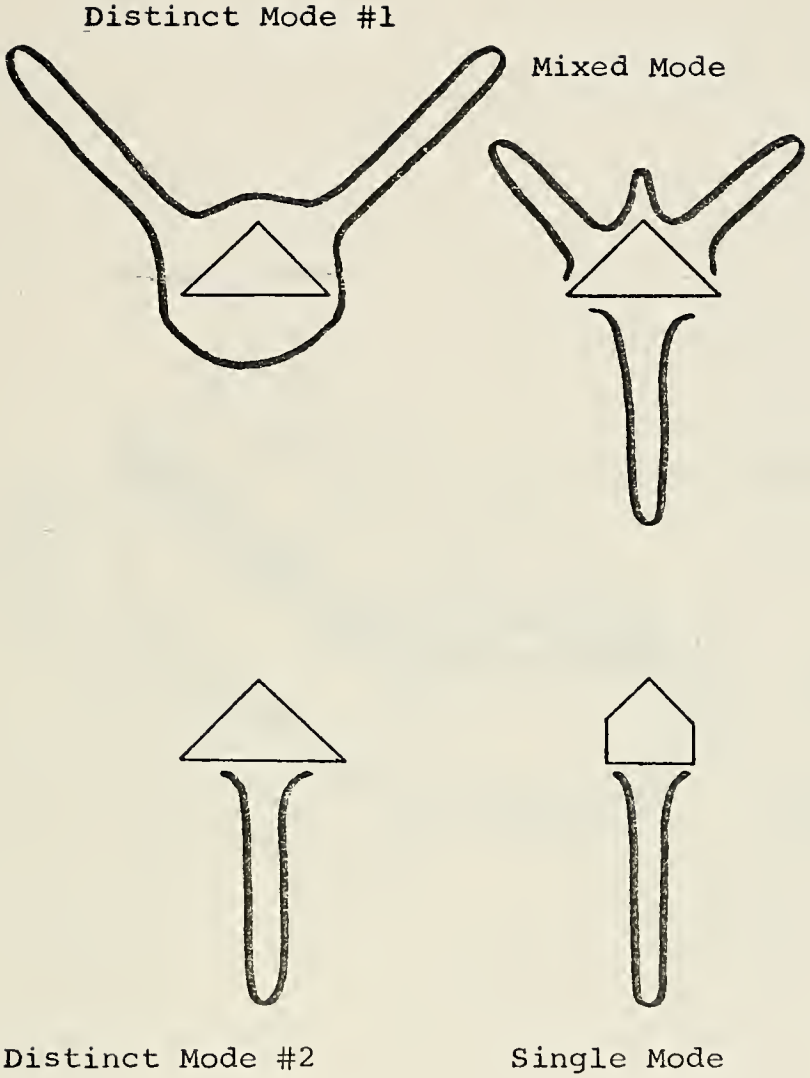

Figure 5. Spatial Radiation Patterns for Diodes with Reflecting Surfaces in Perpendicular Planes [Garfinkel and others 1964].

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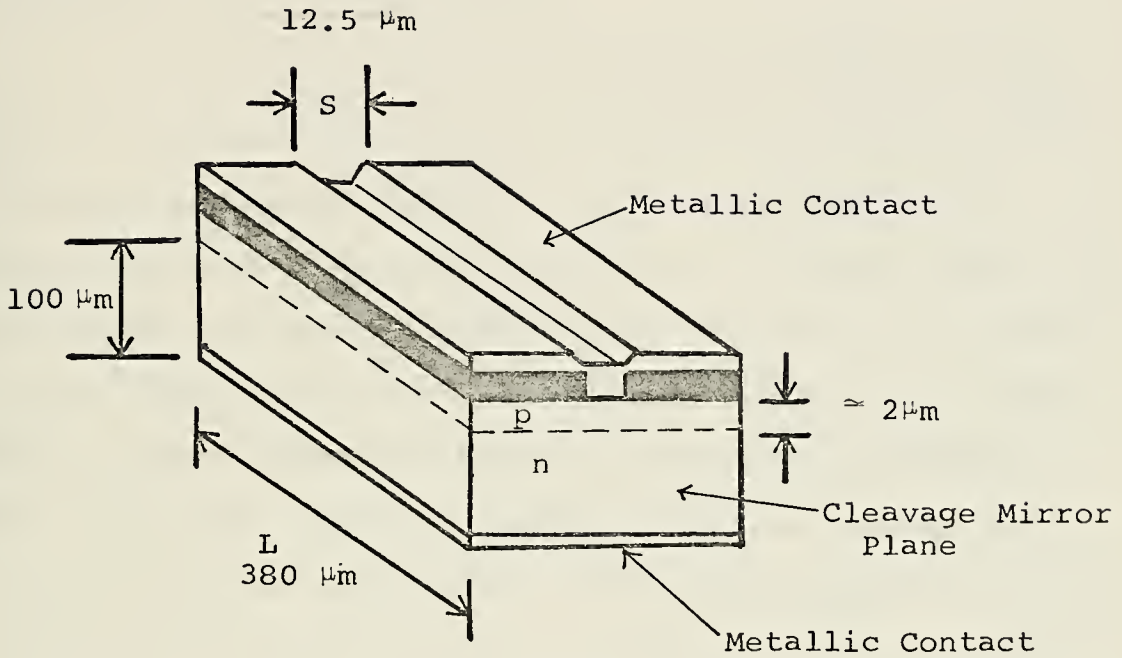

Figure 6. Homojunction Laser with Stripe Geometry [Dyment and D'Asaro 1967].

in March 1963 as one embodiment of Diemer's patent to provide optical confinement through refractive index gradients. Diemer claimed devices that used GaAs on one side of a junction and GaP or a mixed crystal of GaP and GaAs on the other side. A proposal for a heterostructure device that would improve laser performance by increasing electrical confinement of the charge carriers was published by Kroemer in December 1963 [Kroemer 1963].

The patent for the first heterojunction device using gallium aluminum arsenide was filed on 10 June 1968 by Kressel, Hawrylo, and Hawrylo, who were working at RCA [Kressel, Hawrylo, and Hawrylo, 1970]. The basic patent for both single and double heterojunction devices is a continuation of claims (the first of which was filed on 11 October 1968) by Hayashi at Bell Telephone Laboratories [Hayashi 1973]. Both RCA and Bell Telephone Laboratories had been investigating the suitability of using $Ga_{1-x}Al_xAs$ for lasers that emitted visible radiation. Gallium aluminum arsenide has a bandgap of between 1.4 and 1.9 eV allowing emission between 6500A and 8900A. The realization of the single-heterojunction laser as a result of the junction formation processes developed during this research was a milestone in injection laser development.

The performance of the single heterojunction device shown in Figure 7 was so superior to that of the homostructure devices that RCA replaced its entire line of production lasers with single heterojunction devices [Campbell 1972]. The improved performance was attained by introducing

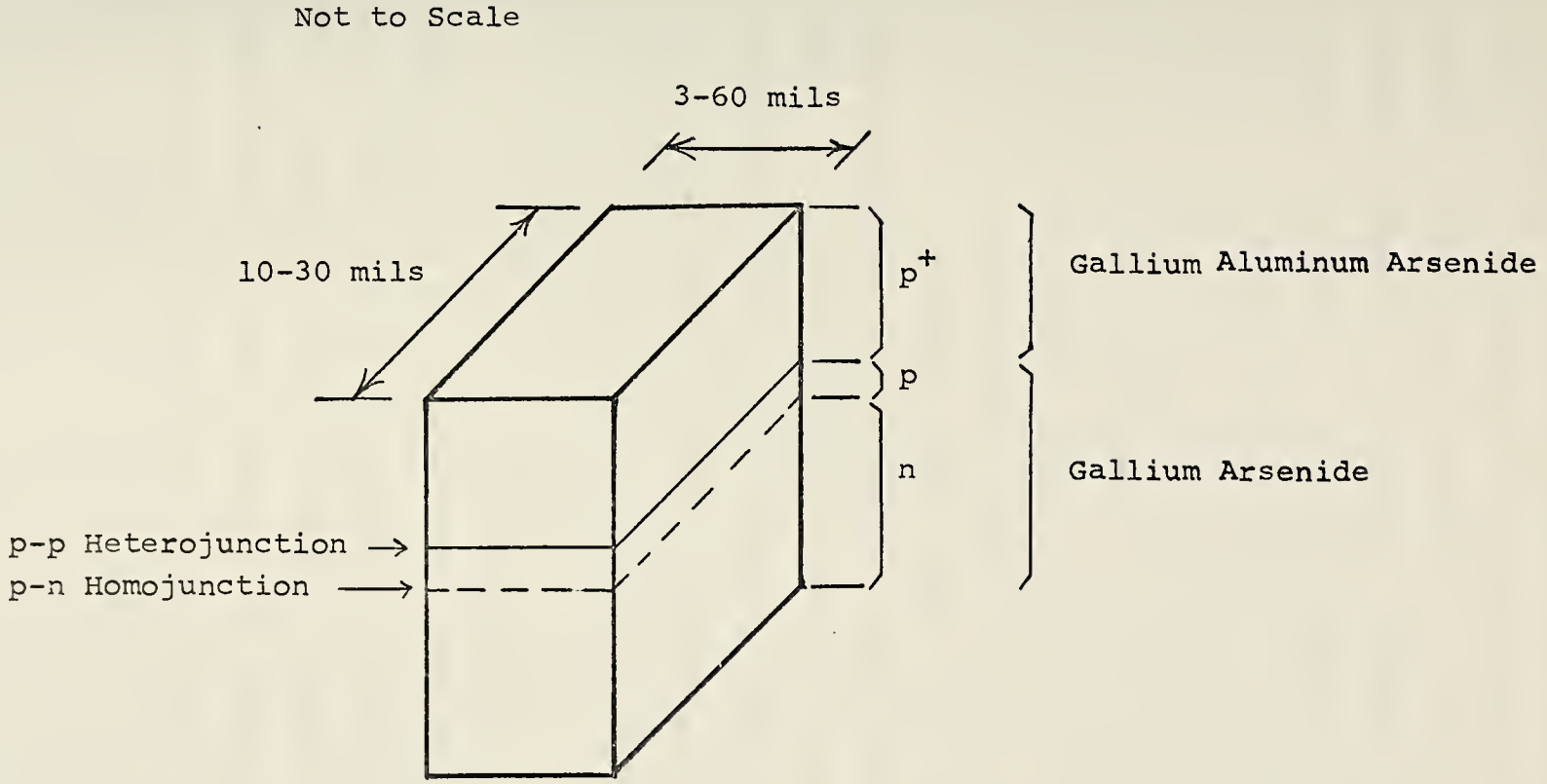

Figure 7. Geometry of the Single Heterojunction Laser [Hayashi 1973; Hayashi and Parish 1970].

a p^+-p gallium aluminum arsenide heterojunction in close vicinity to the GaAs p-n lasing junction. The p^+-p heterojunction affects laser operation in two ways. First the increased bandgap of the gallium aluminum arsenide helps confine injected electrons to a narrower active region than previously possible in homostructure devices. Second, gallium aluminum arsenide has an index of refraction that is less than that of the gallium arsenide in the active region and thus helps to confine the light to the vicinity of the active region which is on the p side of the junction.

The real significance of the single heterojunction laser was that the threshold current did not increase proportional to T^3 as it did for all of the homostructure lasers. The T^3 dependance of the homostructure devices was caused by the active region increasing in thickness due to thermal diffusion of carriers in both the conduction and valence bands as the temperature increased.

The first double heterojunction (DH) device was reported by Alferov in November 1969 [Tsukada 1973]. Hayashi filed patent claims on 1 May 1970 for a double heterostructure device similar to that pictured in Figure 8. This double heterojunction device improves the carrier containment of the SH device by introducing an n-n heterojunction which confines injected holes. The requirements that d_1 be less than the diffusion length of electrons and d_2 be less than the diffusion length of holes limits the maximum thickness (t) of the active region. These conditions arise because for carrier confinement to exist the carriers must be able to reach a

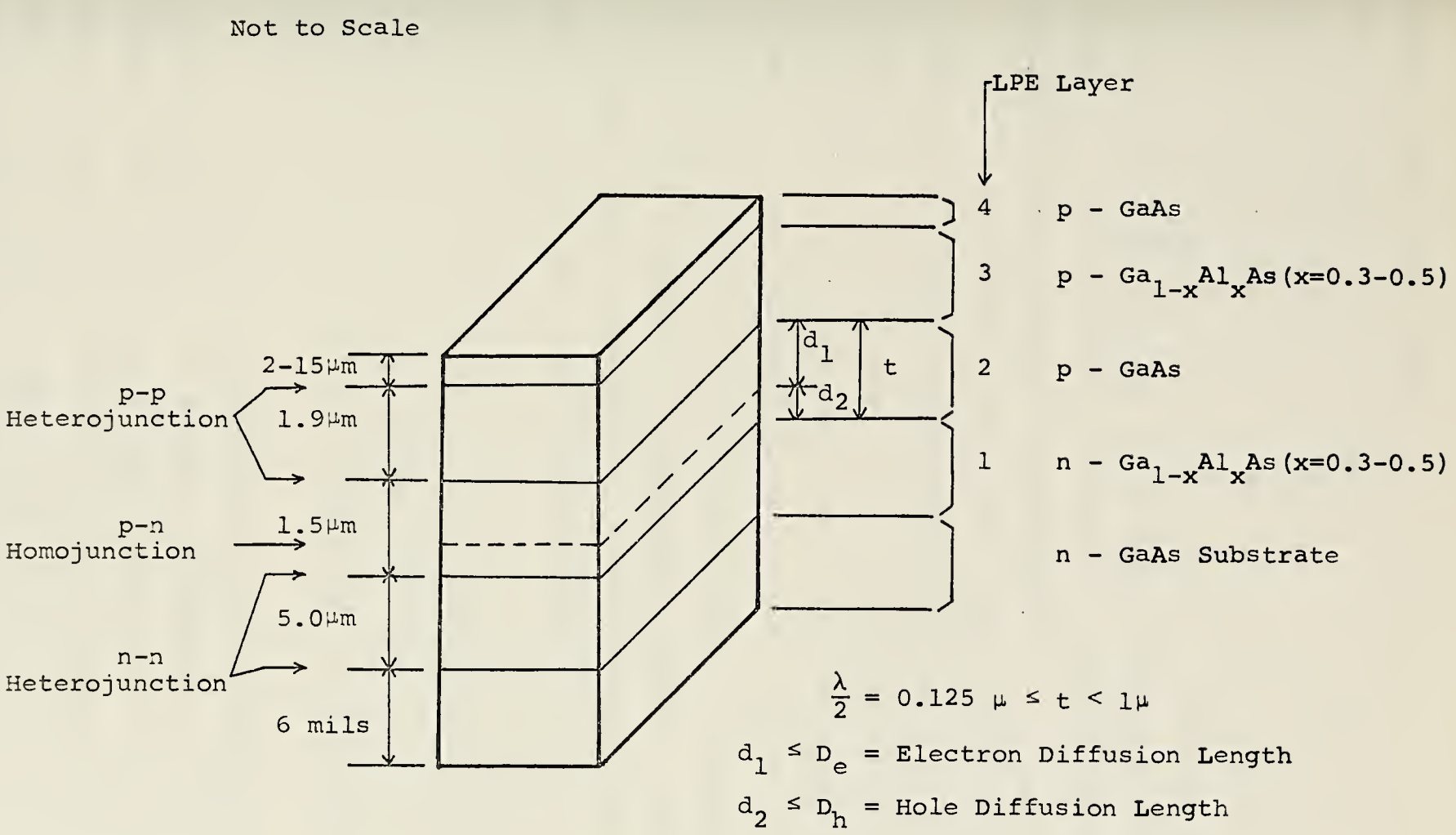

Figure 8. Geometry of the Double Heterojunction Laser [Hayashi 1973].

heterojunction where they can be repelled by the internal fields resulting from the increase in the energy gap. Either d_1 or d_2 can equal zero thus forming an n-p heterojunction. Another requirement is that t must be greater than about one half of a wavelength (λ = 0.25μ in GaAs) so that the optical radiation will be retained in the active region by waveguide effects. If t is less than one half of a wavelength there will be excessive loss due to diffraction.

The large optical cavity (LOC) device pictured in Figure 9 is a double heterojunction device, but in actual operation it is really more like a single heterojunction device that has an n-n heterojunction for added optical confinement. If the thickness d_2 is not less than 1μ the laser will radiate in the close confinement mode of a SH device. If d_2 is less than 1μ the recombination region no longer acts as a lossy waveguide and light is propagated into the n-type gallium arsenide layer that may be as thick as 30μ. When the laser beam is propagating in the LOC mode the optical flux density is the emitting face is reduced thus raising the threshold for catastrophic damage. The increased area of the emitting face also reduces divergence due to diffraction effects.

The double-double heterojunction (DDH), device developed by Hayashi is a further improvement of the DH laser [Hayashi 1972]. For the DH laser both optical energy and charge carriers are confined by the two heterojunctions to a central active region. When a very wide or very narrow active region is required it is more efficient to use one set of

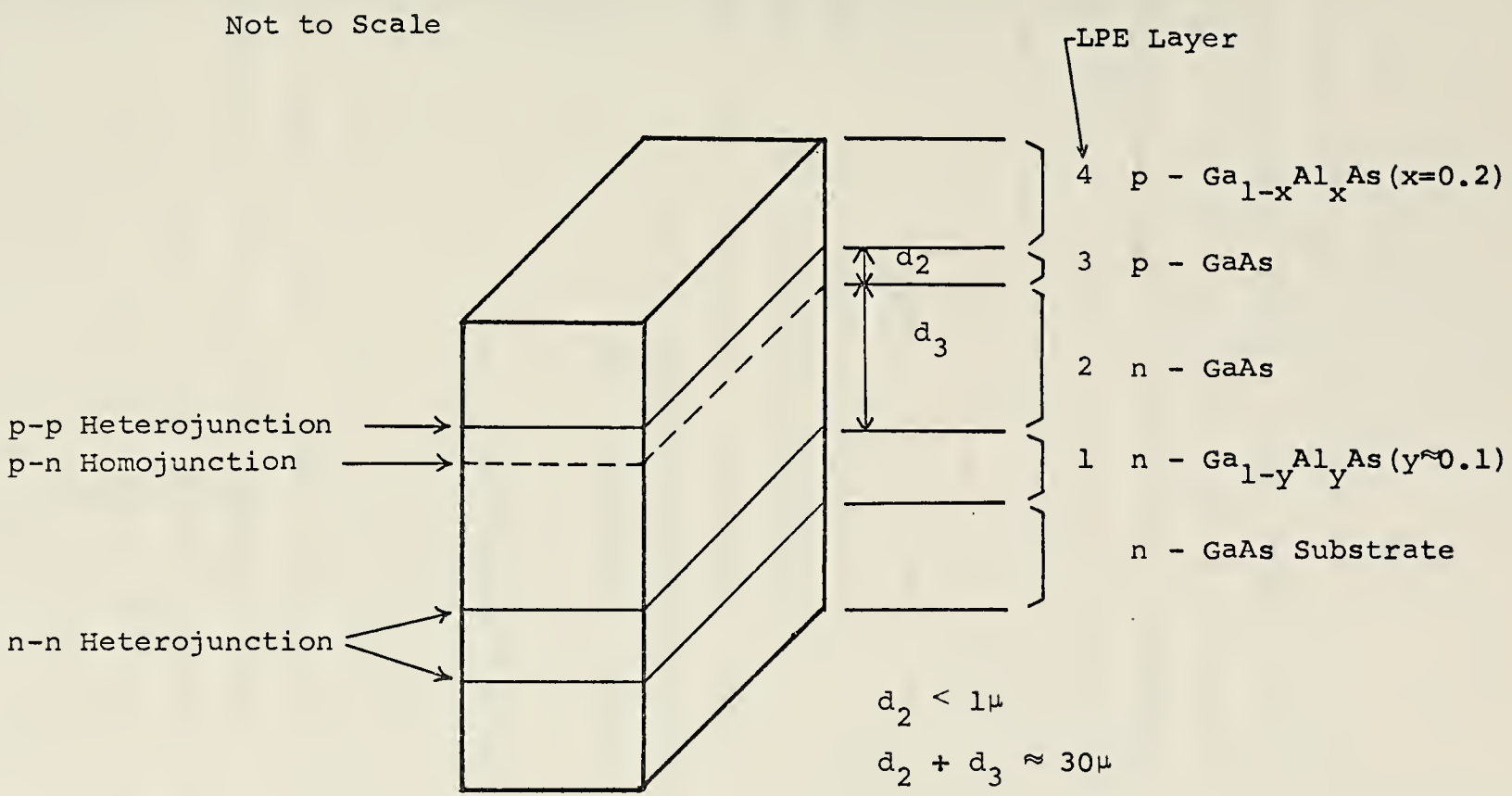

Figure 9. Geometry of the Large Optical Cavity (LOC) Laser [Lockwood and others 1970].

heterojunctions to confine the charge carriers and a different set to confine the optical energy [Thompson and Kirkby 1973]. Considering only the case of a narrow active region, the use of specific heterojunctions to confine the charge carriers to a second active region of width d_2 in Figure 10 removes the restriction imposed on the previous DH device that the width of the central active region be greater one half of a wavelength in order to function as a waveguide. Using the DDH concept the width of the first active region (d_1) is between $\lambda/2$ and λ so that it serves to provide optical confinement and the width of the second active region may approach a value equal to the diameter of a classical electron [Hayashi 1972]. Thus in the DDH device recombination takes place in the second active region (width d_2) which is included within the first active region which serves as a waveguide.

The DH and DDH lasers are limited in output power because the poor thermal properties of gallium aluminum arsenide restrict heat flow on both sides of the active region. The problem also exists in SH devices but is not as severe because only one side of the active region is affected. This is one reason the design of most DH and DDH structures has been directed towards low power single mode cw operation suitable for use in optical communications.

Control of the lasing region by the use of a stripe-geometry, similar to that in Figure 6 for homostructure lasers, was introduced to heterostructure devices by Ripper and others in November 1970 [Ripper and others 1971]. The devices reported by Ripper used stripes that were 400 μ long

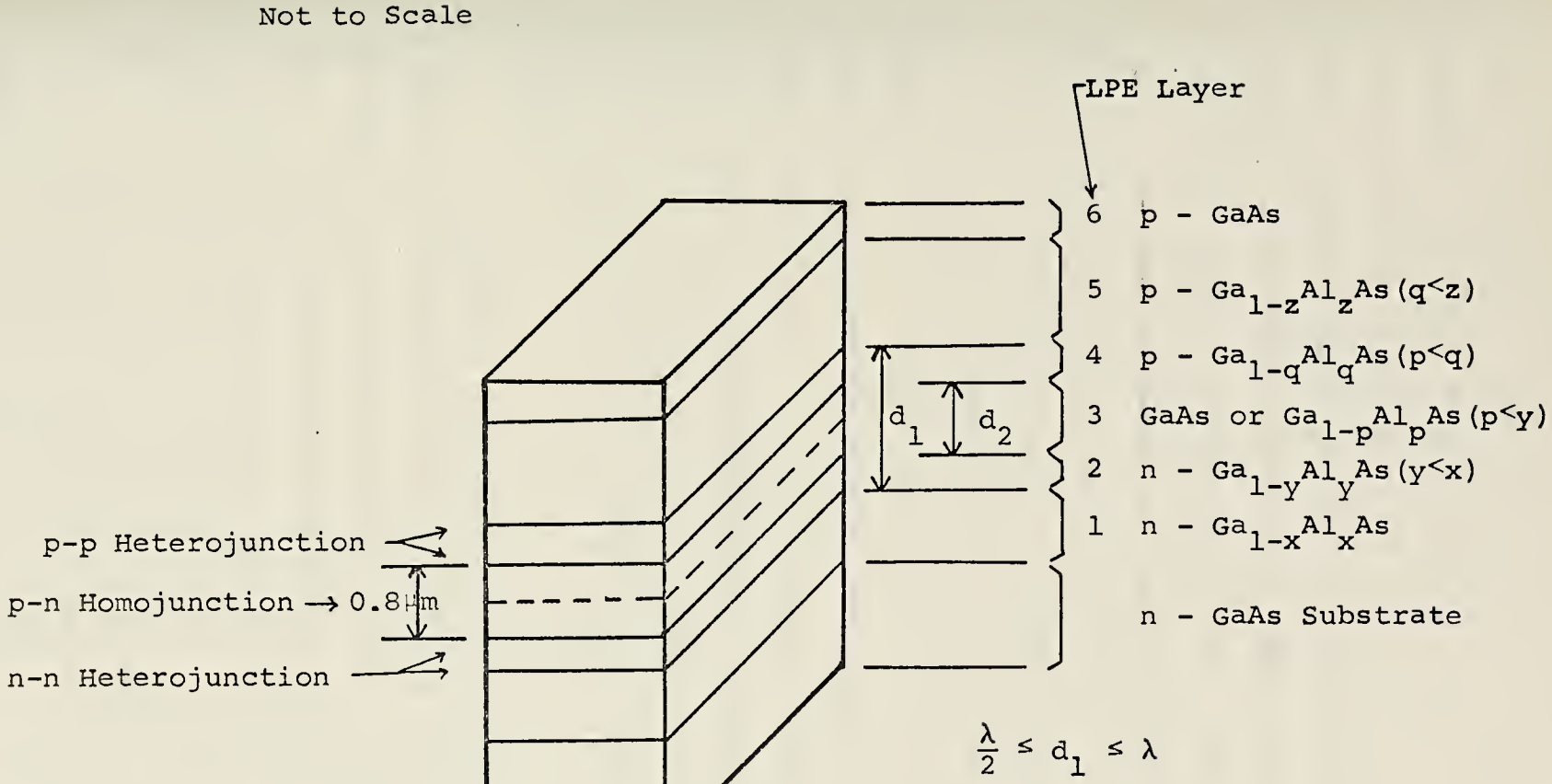

Figure 10. Geometry of the Double-Double Heterojunction Laser [Hayashi and others 1972].

and between 13 and 25 μ wide. The actual width of the active region was about 15 μ wider than the stripe due to current spreading effects. This spreading caused the current density at the junction to be about 30-50% lower than at the contacts. Ripper concluded that use of the stripe-geometry allowed cw operation of DH laser above room temperature primarily because of improved thermal properties of the laser.

The efficiency of homostructure and heterostructure stripe geometry diodes employing metallic stripes with very narrow active regions can be increased by the addition of control stripes located adjacent to the active lasing stripe [Miller 1972]. By operating the control stripes below threshold more electrons in the regions adjacent to the active lasing region will be excited to the conduction band. Since absorption is directly proportional to the number of excited electrons the absorption of tail portions of the Gaussian beam propagating in the active lasing region is greatly reduced.

Dyment, North and D'Asaro reported in 1972 using a proton bombardment method to define the active region of DH lasers into a narrow stripe [Dyment, North and D'Asaro 1973]. The proton bombarded stripe contact laser is formed by masking a thin stripe on the top of a DH diode and then bombarding it with 300 keV protons. A high resistance region which results from defects in the crystal lattice caused by the protons extends completely through the junction plane except in the area under the stripe. This high resistance region limits current spreading and thus restricts the size of the active region.

The problem of current spreading was overcome in the mesa-stripe-geometry DH laser developed by Tsukada and others [Tsukada and others 1972 and 1973]. When the width of the mesa-stripe is reduced to less than 30 μ the threshold current density will start to rise due to diffraction and scattering loss of the light at the sides of the mesa stripe region and due to surface recombination loss of carriers [Tsukada 1973]. Even with this increase the threshold current density for mesa-stripe lasers remains low compared to previous stripe geometry lasers. The high-mesa-stripe (HMS) diode shown in Figure 11 consists essentially of a DH crystal that has been etched to its first epitaxial layer. The main purpose of the HMS structure is to obtain low current operation. The HMS structure will sometimes induce excitation of higher order transverse modes due to the large difference of index of refraction at the side walls. By only etching the DH crystal to just above the active region a low-mesa-stripe (LMS) structure is formed (Figure 12) and the problem of transverse mode control is alleviated. Note the lateral etching of the p-$Ga_{1-x}Al_xAs$ region directly above the active region.

The stripe width can be further decreased by a junction-stripe-geometry DH device reported by Susaki and others [Susaki and others 1973]. In the JS-geometry laser the active region is defined to a narrow stripe by p-n junctions formed by zinc diffusion. The width of the active region for devices reported was about 20 μ however further reduction to about 1 μ is possible.

Not to Scale

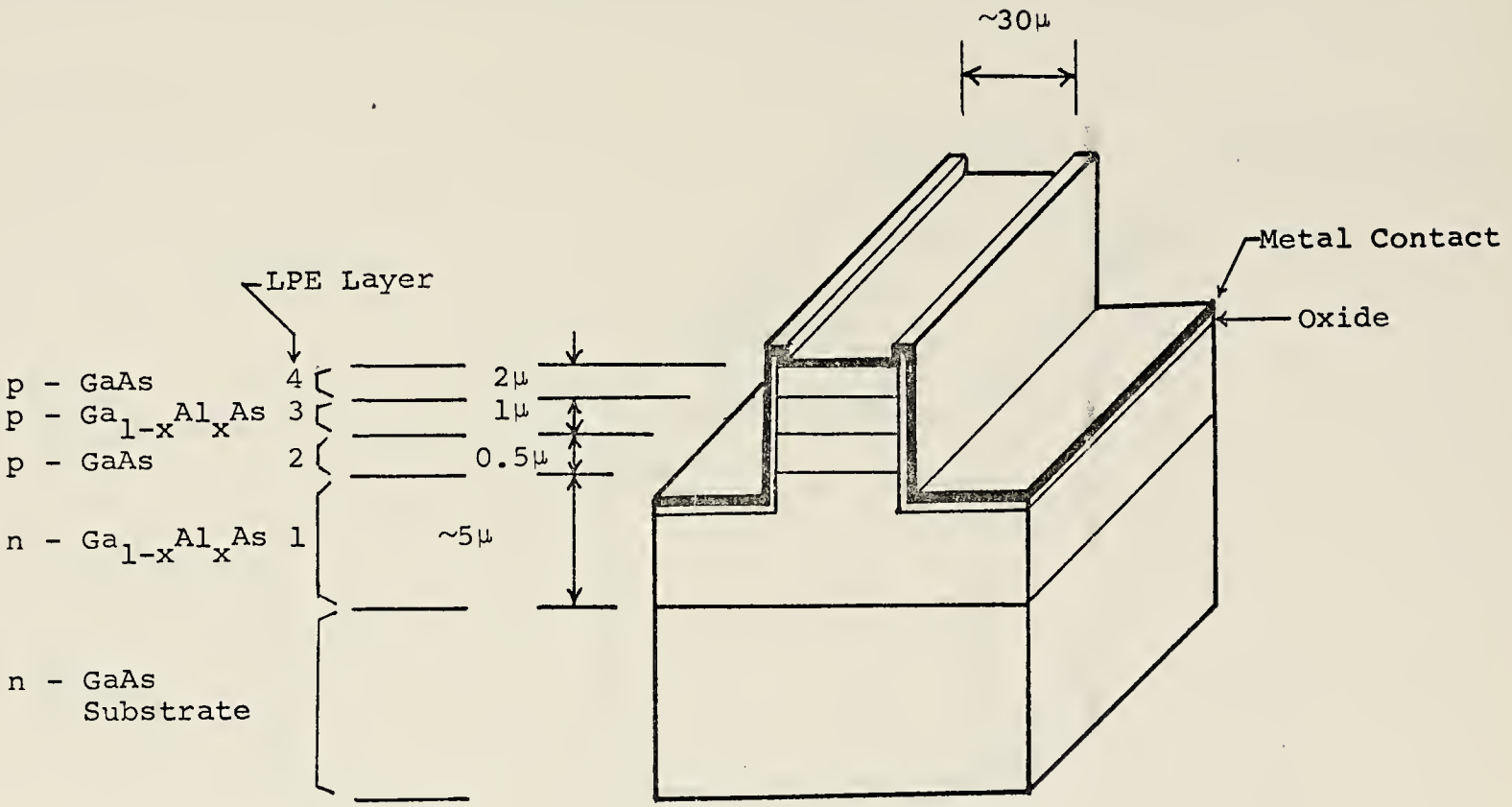

Figure 11. Geometry of the High-Mesa-Stripe Double Heterojunction Laser [Tsukada 1972].

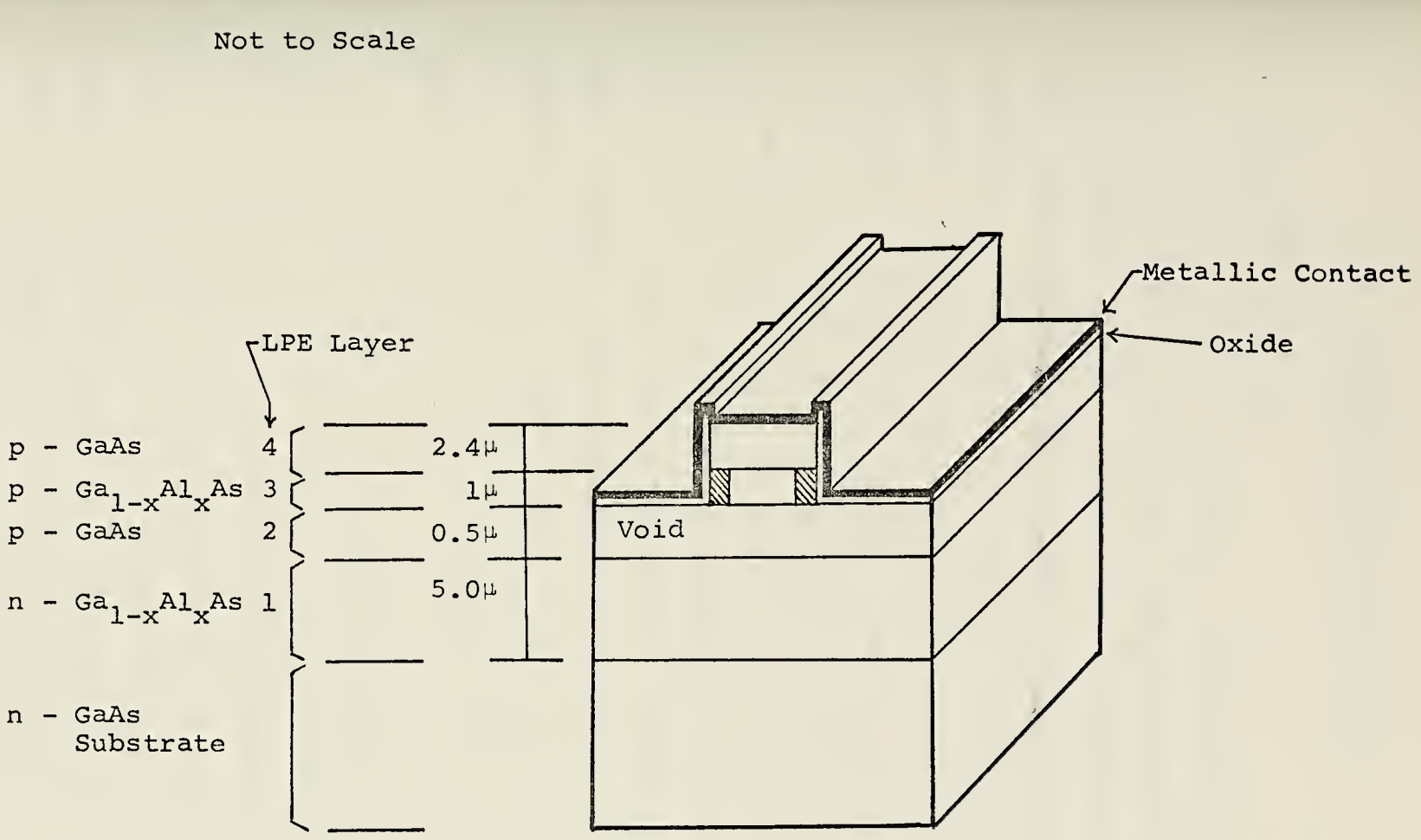

Figure 12. Geometry of the Low-Mesa-Stripe Double Heterojunction Laser [Tsukada 1973].

III. TECHNOLOGICAL FORECASTING

A. TREND EXTRAPOLATION

In the developing science of technological forecasting, the use of trend extrapolation has received the major share of attention. Trend extrapolation is based on the idea that, unless there are major disturbances, whatever has happened in the past will continue to happen in the future. Implicit in this idea is the concept of continuity which is necessary to allow the fitting of some curve or mathematical function to a set of historical data. The forecast is then obtained by projecting the fitted curve into the future. The primary effort of the forecaster is to insure that the data is valid and that an appropriate forecasting method is being employed. Curve fitting techniques, no matter how elaborate, are of little value if the data is not valid or the curve does not really represent information implicit in the data [Martino 1972].

The simplest approach for the extrapolation of future points uses a straight line or a curve fitted to historical points. Typically the growth curve representing the performance of one particular technological approach will take a form similar to one of the three S-curves of Figure 13. By assuming that the process of technological innovation involves a continuous progression of technological approaches, the inherent limits set by the physical parameters of a given approach can be overcome by projecting an envelope curve as

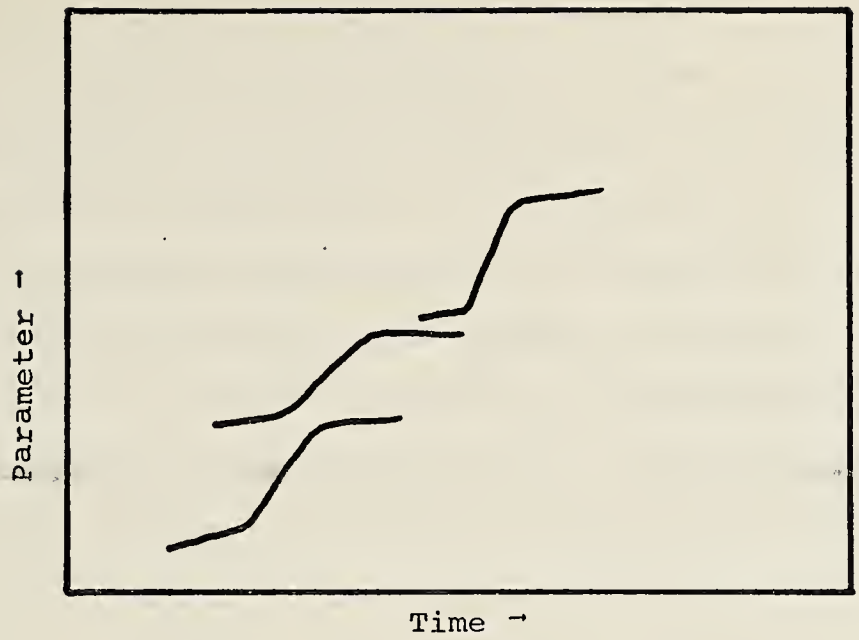

Figure 13. Idealized S-Curves for Technological Approaches.

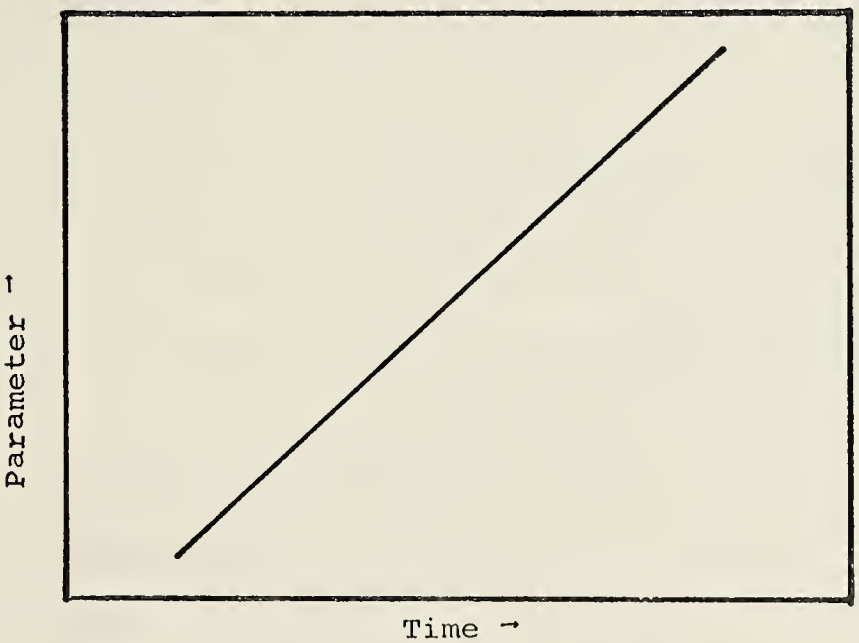

Figure 14. Envelope Curve Showing the Trend Indicated by the Three S-Curves in Figure 13.

in Figure 14. The envelope curve, which shows a general trend, is tangent to the successive S-curves. For the injection laser the S-curves, depending on the performance characteristics represented, can be determined by technological approaches represented by the various structures or fabrication techniques. By using the envelope curve technique it is possible to predict "breakthroughs". The term breakthrough seems to carry with it the idea that there is a sudden increase or advance in technological capability. This is very seldom the case. Generally there is a steady increase in capability up to the point where the technology finally passes from one of its stages of technological development into another. Martino suggests that the most common indication that a "breakthrough" is on the way is the appearance of an innovation that "doesn't quite work" [Martino IEEE 1972]. The injection laser fits this description quite closely.

The use of trend correlation implies the use of known physical or economic relationships between the parameters to be forecast. This relationship can be in the form of an analogy as in the case of Pearl's Law which is expressed as

$$P = \frac{L}{1+a \exp(-bt)}$$

where P = Parameter of interest,

L = Upper limit,

t = Time

a = Constant (dimensionless),

and b = Constant (per unit time).

The exponential dependence of this equation, which was developed to describe population growth as an analogy to the physical process of biological cell growth, produces a symmetrical curve similar to the S-curves of Figure 13.

A non-symmetrical S-curve can sometimes be represented by analogy to Gompertz Law which describes growth phenomena in some areas of economics. Its mathematical expression is

$$P = L \exp\{-b\exp[-kt]\}$$

where P = Parameter of interest,

L = Upper limit,

t = Time,

b = Constant (dimensionless),

and k = Constant (per unit time).

The relationships for trend correlation can link progress to some variable other than time. The technological progress function developed by Fusfeld relates technological progress to cumulative production of the device associated with that technology [Fusfeld 1973]. The technological progress function has the mathematical form

$$T_i = a(i)^b$$

where T_i = value of parameter at the i^{th} unit,

i = cumulative production quantity,

a = a constant associated with unit number one,

and b = the rate of progress, a variable, which is a function of the external environment.

The concept of the technological progress function, which was derived both theoretically and empiricaly resulted from the consideration of microeconomic progress functions

(MEPF's), learning functions, and the forces stimulating the process of technological innovation [Fusfeld 1973b]. The analysis of MEPF's which take the form

$$r_i = a(i)^{-b}$$

where r_i = maintenance, manufacturing, or production cost per unit,

i - cumulative production quantity,

and b = rate at which efficiency is increasing,

resulted in Fusfeld's conclusion that the independent variable in the technological progress function should be the cumulative production quantity (i). This conclusion regarding the mathematical form of the technological progress function was supported by implications taken from consideration of psychological learning functions of the form

$$E_n = K(N)^a$$

where E_n = efficiency in performing the N^{th} task,

N = the cumulative task number,

and K,a = constants.

The third factor that Fusfeld took into consideration involves the links between the rate of innovation and the characteristics of market activity. He suggests that increased market activity stimulates innovation through increased sales, direct exposure to production processes which result in learning, and the ad hoc decision rule used by many companies that a certain percentage of sales is reinvested as research and development. Fusfeld submits in evidence the results of studies that support the idea that "recognition of demand is the most frequent stimulating factor for successful

innovations" and that an "average of 74 per cent of all innovations included in each study were stimulated by market or production needs (as opposed to originating as technical possibilities for which uses were subsequently discovered)" [Fusfeld 1973a]. Fusfeld based his theoretical justification for the use of the cumulative quantity of production as an independent variable on functions that had been developed for relating the rate of patent output to investment and expected profit [Fusfeld 1973b]. Thus the rate of patent output is considered to be a measure of both market activity and technological growth.

The primary benefit derived from relating technological growth to the cumulative quantity of production is that, even if production is not uniformly distributed over time, changes in the rate of technological development will appear as discrete changes in the slope (b) of the logarithm of the technological progress function. The rate of progress coefficient (b) is a function of:

L, the effective size of the technical labor force;

α, an intelligence factor, average educational level;

β, a prelearning factor, average experience level;

I, the level of investment;

j, the rate of change of the level of investment;

δ, a maturation factor, durability of item compatability;

m, the anticipated rate of change of market demand, slope of sales curve;

and c, the communication or diffusion rate.

The coefficient (b) also has the inherent constraints that it be greater than or, equal to, zero and never equal to infinity [Fusfeld 1973b].

Technological growth or improvement of capabilities has generally proven to be exponential in nature [Bright 1973], however this can not be assumed true for all cases [Martino 1973]. When the rate of growth as measured by the cumulative quantity of production is exponential the technological progress function reduces to the same result as that given by conventional trend extrapolation. For example if the technological progress function has the form

$$T_i = a(i)^b,$$

then $$\ell n(T_i) = b\ell n(i) + \ell n(a),$$

and $$\frac{dT_i}{T_i} = b\,\frac{di}{i}\,.$$

If the rate of growth is exponential then

$$i = (\text{constant})\exp kt,$$

$$\ell n(i) = kt + \ell n(\text{constant}),$$

and $$\frac{di}{i} = kdt.$$

Simple substitution yields the result

$$\frac{dt_i}{T_i} = bkdt$$

which when integrated gives the conventional trend forecasting relationship

$$\ell n\, T_i = bkt + (\text{constant}).$$

B. PARAMETERS

1. Selection

Guidance for the selection of forecasting parameters has been provided by Lenz [Lenz 1968], Ayres [Ayres 1968], and Martino [Martino 1973]. According to Lenz, the first step in the selection of parameters is to identify characteristics which have been, or can be, improved. The characteristics selected should be as broad as possible so that a minimum number is needed and should allow quantification so that they can be mathematically represented. Lenz also states that the primary criterion for selection of a parameter should be the usefulness of its trend for making the forecast.

Ayres proposes five rules for the selection of variables for envelope forecasting. These rules are specifically directed towards the broad characteristics which he identifies as being represented by macrovariables. The significant characteristic of a macrovariable is that it can be used to show trends without being tied to a specific approach. For example, when considering coherent light sources the power efficiency would be a macrovariable but the threshold current would be a microvariable because it is tied specifically to the injection laser. Once the macrovariable has been selected it is necessary to determine whether it is intensive (subject to some limit) or extensive (no apparent limit) and whether it is sensitive to environmental conditions. If the variable

is intensive it should be scaled for purposes of the trend extrapolation so that the constraint is effectively eliminated.

Martino has proposed the following five considerations for parameter selection which are not completely unlike those of Lenz and Ayres. According to Martino the parameter chosen must be

1. capable of measurement in quantitative terms,
2. actually representative of the functional capability and be a composite of all parameters which can be involved in a design trade-off,
3. capable of application to different technical approaches,
4. historically documented so that adequate data is available,
5. analysed using data points that have been selected consistantly.

The beam and crystal parameters listed in Table VI represent various injection laser characteristics which have been and still are the subject of research. These parameters are not the broadest ones possible but at least they can be measured in quantative terms and can be applied to the different technological approaches that have evolved in the development of injection laser technology. That these are not broad characteristics is obvious since none of them satisfy Martino's second criteria, because each one of these parameters, to some extent, can be involved in a design trade-off. For example, lowering power output generally results in

TABLE VI. Characteristic Parameters for Injection Lasers.

Beam Parameters

Power

Divergence

Wavelength

Coherence

Polarization

Crystal Parameters

Lifetime

Threshold Current

Operating Temperature

Tunability

Modulation Capability

Modes Propagating

System

Efficiency

Cost of Energy

a reduced threshold current. What is needed are parameters that are less subject to design trade-offs. Those characteristic parameters listed for the system come closer to being representative measures of the functional capability.

Although the efficiencies contain implicit information concerning beam and crystal parameters a broader measure that is a function of four independent variables determined by efficiency, radiance, lifetime, and cost is required to satisfy Martino's second criteria. The relationship between these independent variables is not linear, however a function of the following form will be used as a basis for discussion of the characteristic parameters.

$$M = \frac{(\text{efficiency})(\text{radiance})(\text{lifetime})}{(\text{cost})}$$

The parameter of tunability will be neglected for the purposes of this development.

2. Discussion of Parameters Selected

In an effort to satisfy Martino's second criteria, a broad measure of functional capability has been created that violates his fourth criteria that there be adequate historical data available. This lack of data reflects a hesitancy on the part of research workers to provide lifetime and other engineering data in their papers. As a consequence it is hard to determine levels of development [Anonymous 1971]. The authors of patents are particularly vague concerning the performance characteristics of the devices being described. Generally when data is presented it is an exceptional result or a maximum value that has resulted at the expense of

reductions in other parameters. Very seldom are more than one or two typical parameters listed for the same device. The lack of consistent historical data results in the four independent variables (efficiency, lifetime, radiance, and cost) used to determine the measure of development (M) being approximated by functions developed from data that is not necessarily representative of typical devices.

a. Efficiencies

The most often cited laser parameter is threshold current density (J_{th}). This parameter is of particular interest because it strongly affects the overall efficiency of laser devices. Efficiency is usually broadly identified as quantum or power efficiency.

The specification of a quantum efficiency must be further classified as to whether it is internal or external efficiency and as to whether or not it is incremental. Internal quantum efficiency is defined

$$\eta_i = \frac{\text{number of photons produced within device}}{\text{number of injected carriers}}$$

and the external quantum efficiency is defined

$$\eta_e = \frac{\text{number of photons emitted from the device}}{\text{number of injected carriers}}$$

$$= \frac{P_o/h\nu}{I/e} = \frac{P_o}{IV_g} \qquad (h\nu = E_g)$$

where P_o = power emitted,

$h\nu$ = photon energy,

I = current through device,

e = electronic charge,

V = junction voltage ($V_g = eE_g$)

and E = energy gap.

These definitions are applicable for both spontaneous and stimulated emission. Above threshold, since the output of the laser varies linearly with the current, an incremental (or differential) quantum efficiency is defined which is independent of the current at which the device is operating. For the differential quantum efficiency, $\Delta\eta_i$ and $\Delta\eta_e$, the denominators of the above equations should read: number of injected carrier above threshold. Thus use of the differential quantum efficiency

$$\Delta\eta_e = \frac{P_o}{(I-I_o)V_g}$$

where I_o = current at threshold

is restricted to operating points above threshold. The differential form of the external quantum efficiency simplifies the measurement process because only the ratio of photodetector output to laser input current need be measured thus eliminating the need for determination of P_o. In actual practice $\Delta\eta_e$ is the measured quantity and $\Delta\eta_i$ is calculated by taking into consideration photon losses within the device. This is accomplished by expressing $\Delta\eta_i$ as a function of mirror reflectivity as follows:

$$\Delta\eta_e = \Delta\eta_i \frac{\frac{1}{L}\ell n\frac{1}{R}}{\alpha + \frac{1}{L}\ell n\frac{1}{R}}$$

where R = reflectivity coefficient (if two different reflectivities are involved $R = R_1R_2$

L = length of cavity

α = internal loss coefficient.

The term $\frac{1}{L} \ell n \frac{1}{R}$ is related to the number of photons lost through the ends and the term $\alpha + \frac{1}{L} \ell n \frac{1}{R}$ is recognized as the gain per unit length.

The quantum efficiencies do not include any power dissipated in the diode series resistance (R_d). The input power P_i is given by,

$$P_i = IV_g + I^2R_d$$

and thus the power efficiency is defined

$$\eta_p = \frac{P_o}{IV_g + I^2R_2} .$$

The power efficiency is determined by measuring P_o, I and R_d. The importance of threshold current can be seen from this equation where in order to maximize η_p it is desirable for I to be as low as possible.

The threshold current density J_{th} is defined by

$$J_{th} = \frac{g}{\beta} = \frac{1}{\beta} \left(\alpha + \frac{1}{L} \ell n \frac{1}{R}\right)$$

where β = gain coefficient. Looking again at the equation

$$\Delta\eta_e = \Delta\eta_i \frac{\frac{1}{L} \ell n \frac{1}{R}}{\alpha + \frac{1}{L} \ell n \frac{1}{R}} = \frac{\frac{1}{L} \ell n \frac{1}{R}}{\beta J_{th}}$$

it can easily be seen that $\Delta\eta_e$ is also a function of threshold current.

In addition to the variables already presented the junction temperature and crystal doping also affect the efficiencies. The effect of temperature has been eliminated from the measure of development (M) by only considering data for room temperature devices. No specific consideration has

been given to doping materials or concentrations when collecting historical data. The effects of materials and dopants are included in the constants α and β.

b. Radiance

Lasers in general are uniquely distinguished from other light sources by their radiance [Heard 1968]. Radiance (N) is defined [Wolfe 1965] as the radiant power per unit solid angle per unit projected area and is expressed

$$N = \frac{\partial^2 P}{\cos\theta \, \partial A \, \partial \Omega} \qquad (w\ sr^{-1}\ cm^{-2}).$$

Spectral radiance (N_λ) is defined [Wolfe 1965] as the radiance per unit wavelength interval and is expressed

$$N_\lambda = \frac{\partial N}{\partial \lambda} \qquad (w\ sr^{-1}\ cm^{-2}\ \mu^{-1}).$$

The measurement of spectral radiance includes the measurement of time dependent power, power density, beam divergence, polarization, coherence, and spectral content [Heard 1968]. It would appear that this would be a good measure of the beam characteristic parameters, however due to the paucity of data it can only be approximated by peak or average power.

Sommers indicates that power output is associated with the number of cavity modes present and that there is a critical parameter on the order of 10 mW per normal mode [Sommers 1973]. At the maximum power output, which is determined by the limit for facet damage, up to a thousand modes can share the power. Sommers' explanation is based on findings that indicate the existence of an inherent nonlinearity in semiconductors that spreads the coherent radiation among the normal modes. This nonlinearity also accounts for the

phenomenon of filamentary lasing which was previously thought to be caused by inhomogenieties within the active region.

c. Lifetime

Injection laser lifetime is a subject for which very little data is available before 1970. The lifetime of the laser is determined by degradation processes that can be classified as either catastrophic or gradual. Most of the early papers on degradation deal primarily with the catastrophic results of high optical flux densities. Recently the emphasis has been on the gradual degradation processes involved in the relatively low power CW devices being developed for communications purposes.

Catastrophic degradation involves mechanical damage to the laser facet. This damage is the result of elastic strains created within the crystal, possibly due to stimulated Brillouin emission with the resultant formation of shock waves [Nelson and Kressel 1967]. The problem of catastrophic degradation has been reduced through the use of antireflective SiO films and the large optical cavity (LOC) laser structure which reduces the emitted flux density at the facet [Kressel and others 1971].

The processes of gradual degradation result in a decrease in efficiency along with an associated increase in threshold current. Two basic proposals have been advanced to explain the mechanisms of gradual degradation. Hakki and Paoli have suggested that localized regions of high absorption are formed within the active region [Paoli and Hakki 1973] whereas Newman and Ritchie conclude that the degradation is

due to an increasing amount of nonradiative recombination [Newman and Ritchie 1973]. By examining degraded diodes with a Scanning Electron Beam Microscope (SEM), Nannichi and Hayashi have virtually established the fact that fast recombination and nonradiative regions exist [Nannichi and Hayashi 1974]. These regions which affect degradation are caused by crystalline defects created by stresses due to the mismatch of lattice constants at heterojunctions and local heating due to increasing threshold current.

The requirement to reduce threshold current has dominated the design of recent laser structures with improved lifetimes. The result has been that power has been traded for the increased lifetime.

d. Cost

The trend of laser cost will be approximated by data for the cost per watt of peak pulsed power. The cost of laser fabrication contains implicit information on the state of manufacturing techniques and diode reproducibility. Currently only single heterostructure lasers are available commercially so the trends derived can only be considered as precursors of overall trends that may develop when the technical approaches now in the laboratory become commercially available. One of the major problems with the injection laser has been and still is reproducibility. A trend of decreasing cost is an indication that technological development has progressed to the point where diodes with a reasonably consistant level of performance can be mass produced.

C. PRESENTATION OF DATA

1. Cumulative Production Data

The cumulative production quantity (i) required for Fusfeld's technological progress function was determined by using the cumulative number of semiconductor laser patents filed (CSUM) and the cumulative number of technical reports computer retrieved (CREP) by the Defense Documentation Center. The use of CREP as a measure of inventive activity was suggested by Gilfillan [Gilfillan 1962] and was included because Sanders does not consider patents to be a good measure of technological progress [Sanders 1962].

The cumulative number of patents filed is plotted against the date in Figure 15 and the logarithm of the cumulative number (LCSUM) is plotted against the date in Figure 16. Although patent data was collected through January 1974 only data points through December 1970 have been considered because the average lag between the date of patent application and issuance is almost three years. Linear regression using the method of least squares was performed on the data of Figures 15 and 16. The best coefficient of determination[4] for the longest time base was obtained when fitting a straight line to the plot of CSUM versus date. The plot of the logarithm of the cumulative sum of patents filed (LCSUM) against the

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[4] The coefficient of determination (r^2) is a number between 0 and 1 which describes the "goodness of fit" of the equation determined by the regression. When r^2 is close to 1, the equation closely describes the data; when r^2 is close to 0, the equation is not a good statement of the relationship between the data.

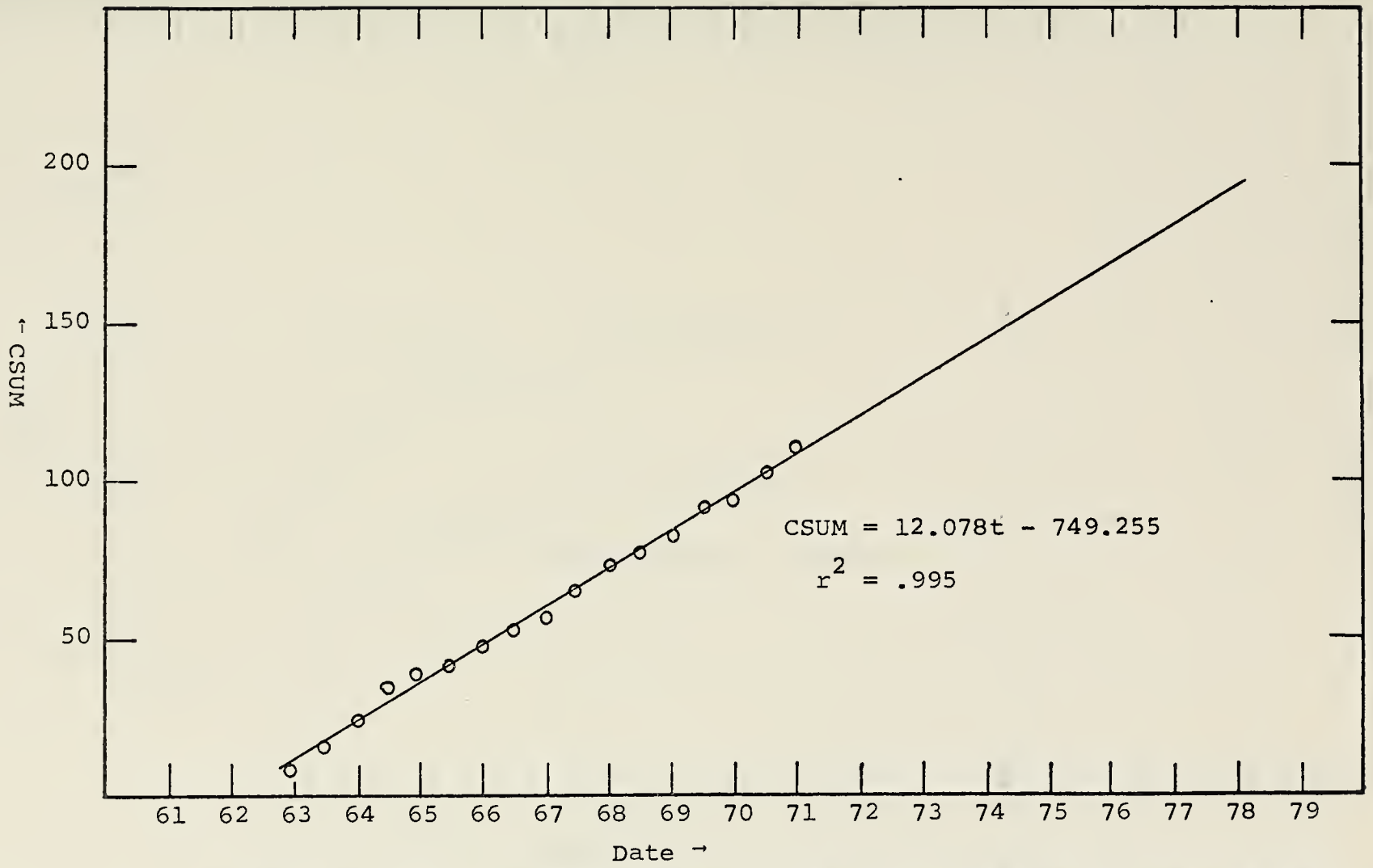

Figure 15. The Cumulative Number of Semiconductor Laser Patents Filed (CSUM) versus Date.

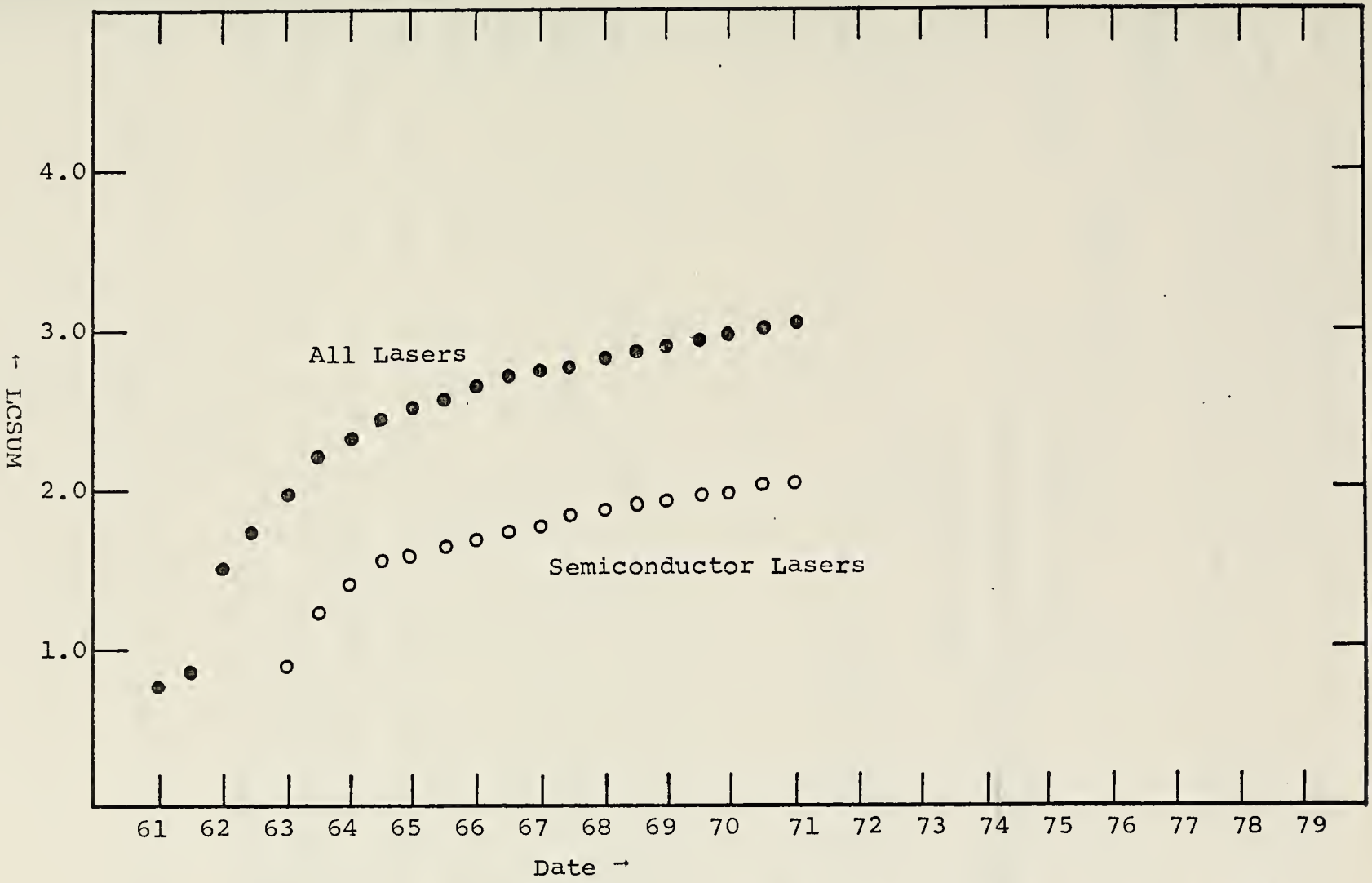

Figure 16. The Logarithm of the Cumulative Number of Patents Filed (LCSUM) for all Classes of Lasers and for Semiconductor Lasers versus Date.

date is reasonably linear in places as can be seen from the data in Table VII however the time base is much shorter. Assuming that patent data is a measure of technological progress, the following cumulative production function is appropriate:

$$\text{CSUM} = i(t) = Kt + C$$

where K = constant (year^{-1})

t = date expressed as last two digits of calendar year

and C = constant.

The resulting technological progress function takes the form

$$T_i = a(Kt + C)^b$$

and $$\ell n\, T_i = \ell n\, a + b\, \ell n(Kt + C).$$

Figure 17, which is a logarithmic plot of the cumulative number of reports (LCREP) against the date, shows a definite exponential increase and using the method of least squares a straight line is easily fitted to the data points between 1 January 1966 and 1 January 1973. The time lag between publication and listing did not often exceed one year therefore Figure 17 includes points through December 1972. Assuming that LCREP is an indication of cumulative production then the following exponential form for (i) is appropriate:

$$i(t) = e^{kt+c}.$$

This results in a technological progress function of the form

$$T_i = a(e^{kt+c})^b = ae^{bkt+bc}$$
$$= Ae^{Bt}$$

TABLE VII. Cumulative Production Data for Figures 16 and 17.

Catagory	- Period - Start	Thru	K	C	r^2
All Laser Patents	Jan 61	Dec 62	1.481	- 8.955	.943
	Jul 64	Jun 67	0.265	-11.489	.995
	Jul 67	Dec 70	0.166	- 4.757	.999
	Jul 64	Dec 70	0.207	- 7.615	.983
Semiconductor Laser Patents	Jan 63	Jun 64	0.915	-55.442	.953
	Jul 64	Jun 67	0.210	-10.055	.940
	Jul 67	Dec 70	0.139	- 5.160	.991
	Jul 64	Dec 70	0.184	- 8.324	.977
Reports Listed	Jan 63	Dec 66	1.201	-76.158	.981
	Jan 67	Dec 72	0.43	-27.26	.998

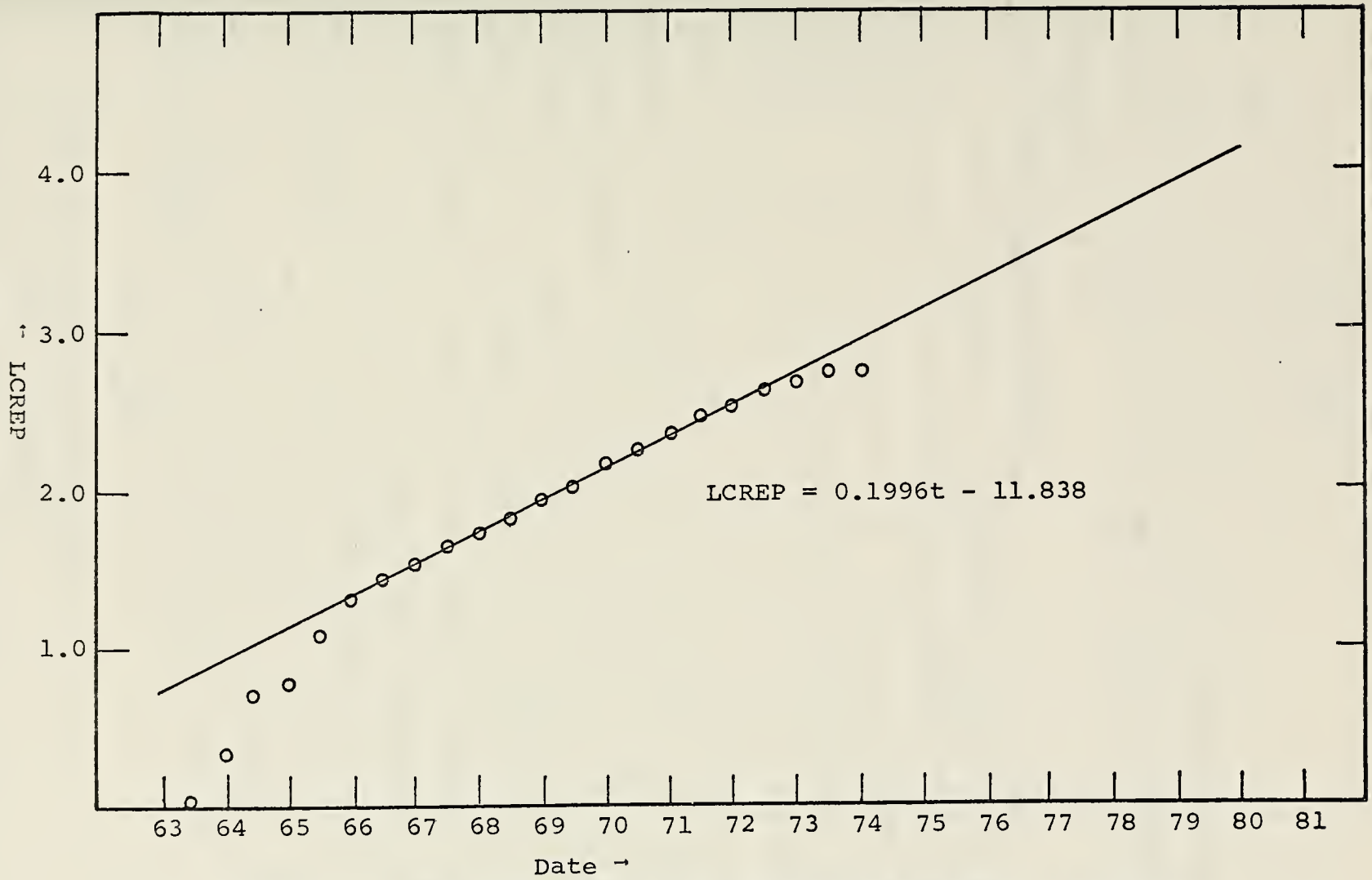

Figure 17. The Logarithm of the Cumulative Number of Reports Retrieved (LCREP) versus Date.

where $\ell n\, T_i = \ell n\, a + b\, \ell n(e^{kt+c}) = \ell n\, A + Bt,$

$A = ae^{bc},$

and $B = bk.$

This equation has the same form as the conventional trend forecasting relationship which assumes exponential growth as a function of time.

2. Rate of Progress Data

The data presented is summarized in Tables VIII and IX. The values for the characteristic parameter (M) were calculated using the values for η_p, P_{avg}, L, and \$/watt shown in Table X which lists representative current values, the date they were reported, and the number of years for which data was available. Graphs from which the values for the characteristic parameters listed in Table VIII were determined are included in Appendix B. For each of the extrinsic parameters the logarithms of parameter values are plotted against the date, LCSUM, and LCREP. The logarithms of intrinsic parameter values are first plotted against the date and then scaled against the date, LCSUM, and LCREP. The scaling employed for these intrinsic parameters is similar to that used by Martino [Martino 1973]. In the case of an upper limit the parameter of interest P is converted to a scaled parameter P* by use of the following formula:

$$P^* = \frac{A}{L-P}$$

where A = arbitrary constant,

and L = limit approached.

In the case of a lower limit the formula $P^* = \frac{A}{P-L}$ is used.

TABLE VIII. Summary of Data Presented. (An asterisk indicates that forecast projection exceeds the data base).

	Trend Extrapolation			
	Function of Time		Function of Cumulative Production	
	Not Scaled	Scaled	LCSUM	LCREP
Differential Quantum Efficiency $\Delta\eta_e$				
1976	1940%	79%	68%	71%
1980*	21,000%	88%	74%	81%
Power Efficiency η_p				
1976	66%	24%	23%	26%
1980*	211%	34%	26%	34%
Threshold Current J_{th} (amp cm^{-2})				
1976	1.0×10^{-3}	110	135	257
1980	2.5×10^{-5}	100	105	133
Average Power (P_{avg}) (Watts)				
1976	.0247	extrinsic	.0206	.0239
1980	.0433	extrinsic	.0264	.03839
Lifetime L (hours)				
1976	5×10^4	extrinsic	1.5×10^4	4.9×10^4
1980	8×10^6	extrinsic	2.3×10^5	6.3×10^6
Cost ($/Watt)				
1976	1.71	1.80	1.90	1.80
1980*	0.76	1.20	1.12	0.86
Characteristic Parameter (M)				
1976	476	164	37	169
1980*	9.6×10^5	349	1.4×10^3	9.8×10^4

TABLE IX. Progress Constants

Parameter	Rate of Progress (b)	
	LCSUM	LCREP
$\Delta\eta_e^*$	.843	.228
η_p^*	.186	.058
J_{th}^*	7.492	.899
L	11.100	2.773
P_{avg}	.991	.285
W/$	2.108	.4187

TABLE X. Representative Current Values for Parameters

Parameter	Value	Date	Data Basis (Years)
$\Delta\eta_e$	56%	Apr 70	5.3
η_p	20%	Apr 71	5.5
J_{th}	800 A/cm^2	71	9
P_{avg}	.015 watt	Jan 74	8.5
L	6000 hours		
$/Watt	2.86	Jan 74	3.0
M	6.30	Jan 74	3.0

a. Efficiencies

The data for the three efficiency parameters (external differential quantum efficiency ($\Delta\eta_e$), power efficiency (η_p), and threshold current density (J_{th})) was selected by consistantly choosing exceptional values. The external differential quantum efficiency and the power efficiency both approach the limits of 100 per cent and are therefore intrinsic. The threshold current density is also intrinsic as it appears from Figure 18 to approach a practical limit of about 100 amp cm^{-2}.

b. Power

The data for power was primarily extracted from trade magazines by selecting the single room temperature diode that delivered greatest average power. All of the data considered was for pulsed operation and the average power was determined by multiplying peak power by the duty cycle. There are some exceptional CW devices that have demonstrated greater average power in the laboratory but they were not considered. Figure 19 shows the power reported for some recent injection lasers designed for CW operation. The power trend of these diodes is more indicative of the emphasis on longer life and fewer modes than of any capacity for increased power output.

Meaningful data was difficult to obtain because the following information is seldom provided along with values for the output power.

-- Duty cycle (pulse width; pulse frequency)

-- Whether total power or from one facet

-- Diode temperature

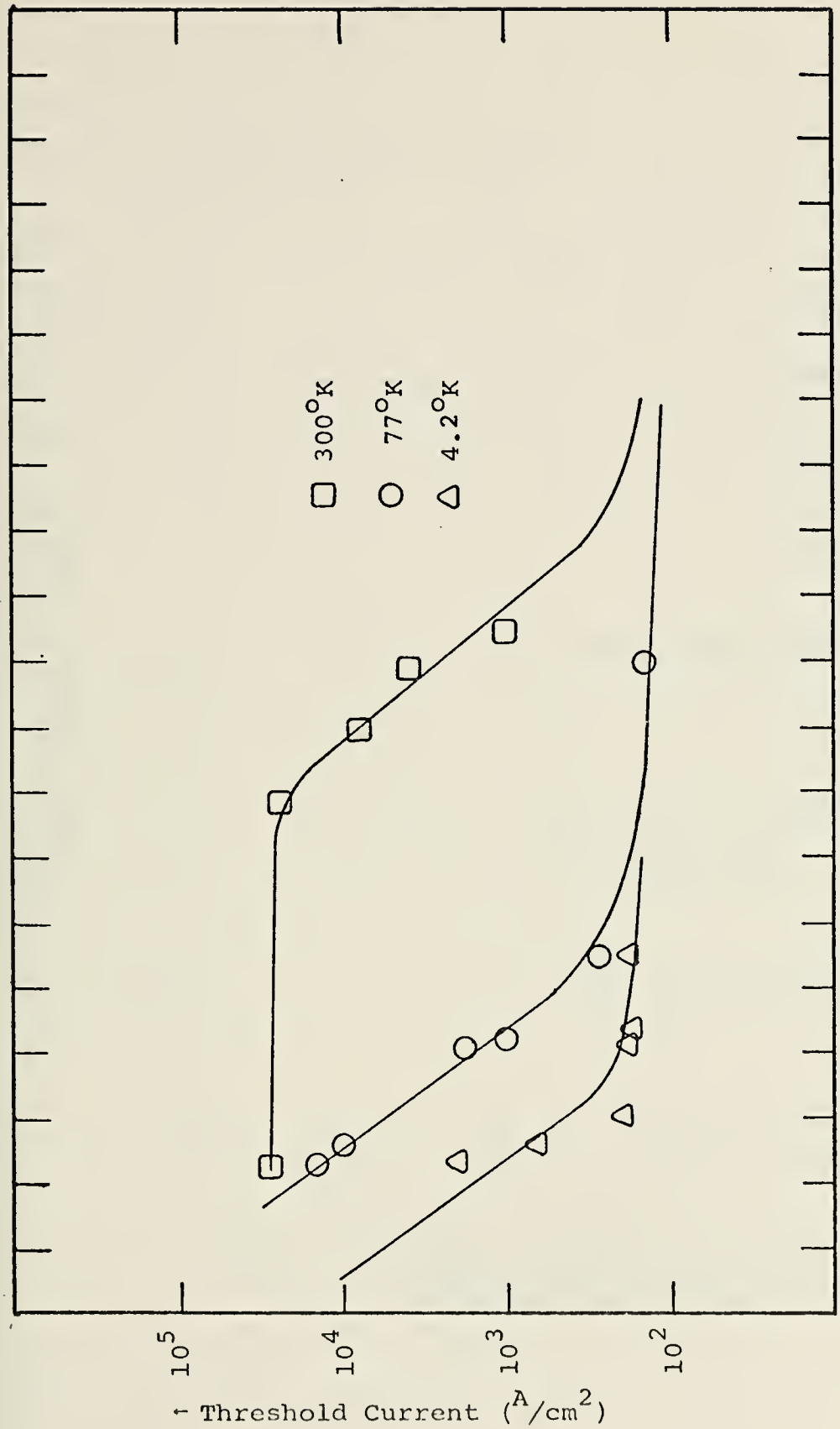

Figure 18. Threshold Current at 4.2°K, 77°K, and 300°K (amps cm^{-2}) Versus Date.

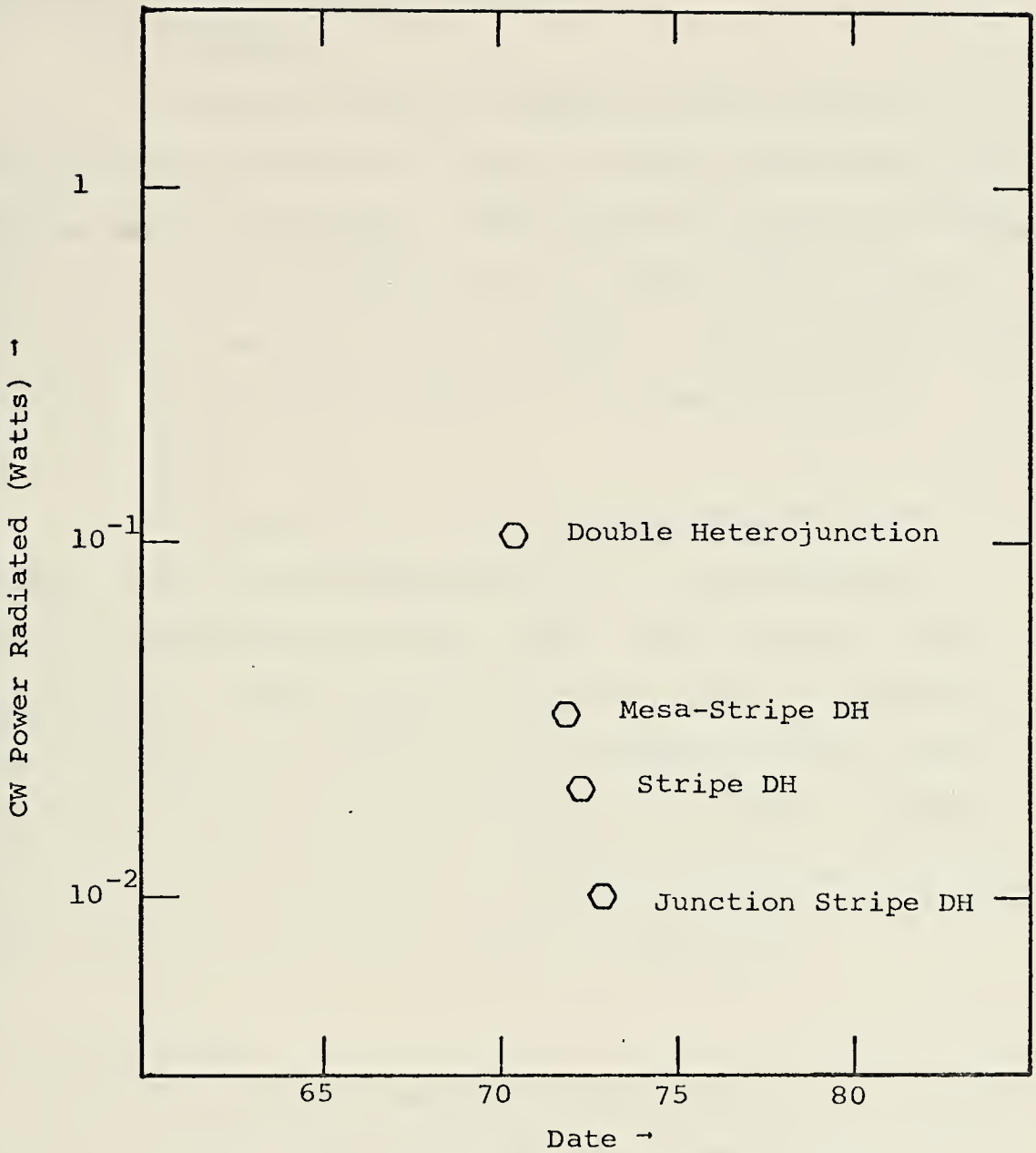

Figure 19. Typical CW Power Output (Watts) at Room Temperature for Recent Laser Structures Versus Date.

Often power output is reported in relative units or in units of watts per cm^2 with no additional information. Peak power in excess of 70 watts has been reported for room temperature diodes [Anonymous 1972].

c. Lifetime

Lifetime data was extracted from technical journals and was determined for pulsed diodes by multiplying the lifetime by the duty cycle. The emphasis on increased lifetime that dominates current research makes recent data for this parameter relatively more abundant. This parameter is extrinsic and therefore scaling has not been employed.

c. Cost

The cost per watt values were determined by dividing cost by the peak power of the room temperature devices selected for the power data. Since cost per watt is intrinsic in that it has an ultimate limit of zero the trend extrapolations were scaled by simply plotting watts per dollar. Figure 20 which indicates a dramatic decrease in the cost per watt with time includes data based on array output powers with no restriction on temperature.

D. CONCLUSIONS

One of the primary benefits of the technological progress function is that changes in the rate of technological development will appear as discrete changes in the slope of the function. There were no changes indicated by the technological progress function or the time base trend extrapolations.

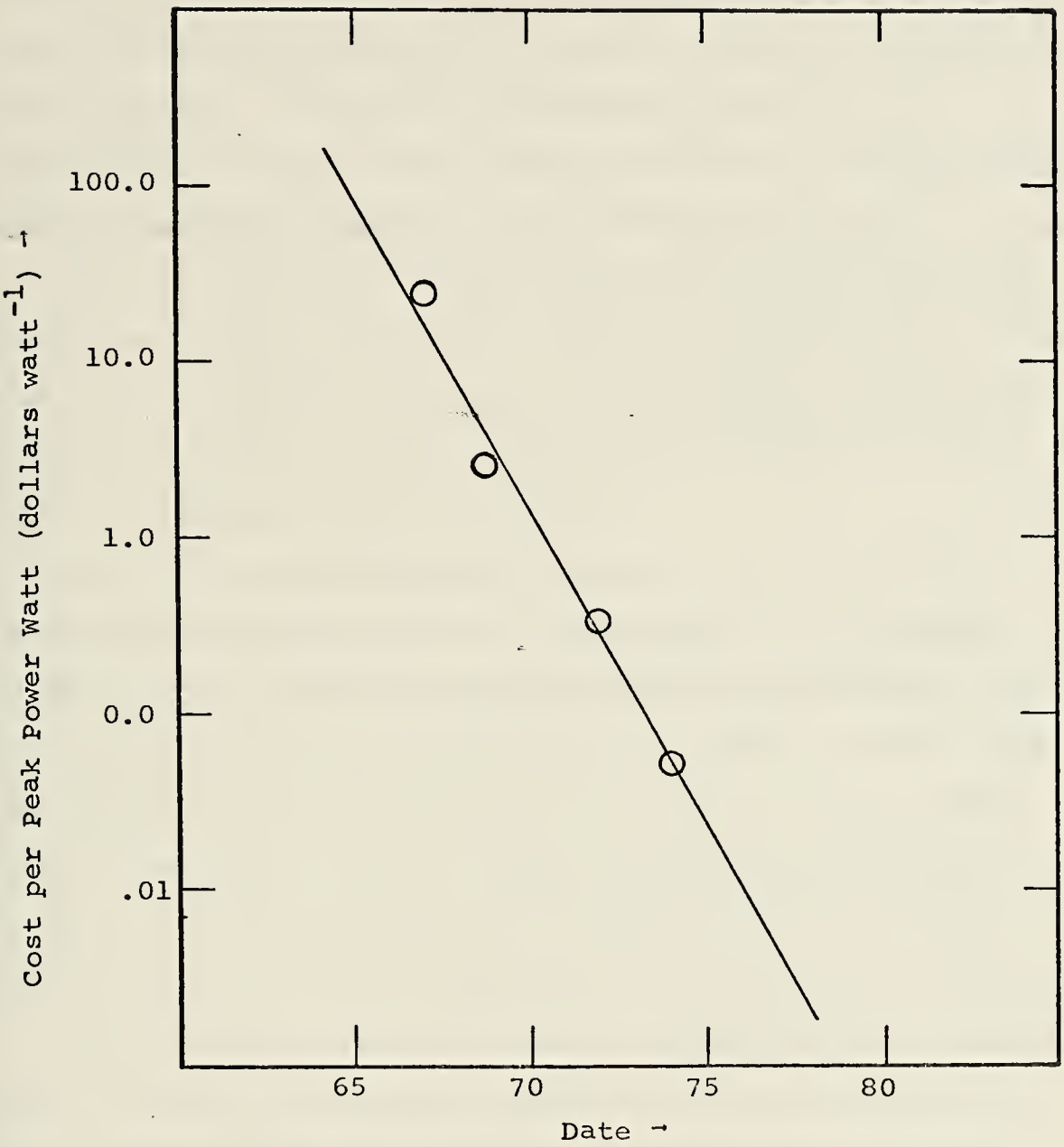

Figure 20. Cost per Peak Power Watt (dollars watt^{-1}) Determined Using Data for Arrays and all Operating Temperatures Versus Date.

Fusfeld's assumption that patent output is a measure of market activity appears to be justified by the actual performance of the market (Figure 21). The most conservative values for the forecasted parameters resulted from using the technological progress function and cumulative number of semiconductor patents. Since the actual market growth is not exponential the use of the cumulative number of reports as a measure of market activity is not valid in this case.

The importance of a broad characteristic parameter that satisfies Martino's selection criteria is questionable in the case of the injection laser. The most important trends deal with the specific parameters that limit feasible or economically competitive use of the laser.

The preliminary historical survey of injection laser development was primarily an investigation of the various types of laser structures and why they were developed. During the course of this investigation it was determined that the technology of laser structures was tied to the technology of GaAs processing. For this reason it was concluded that a forecast for injection laser development could be inferred from a forecast for the technology of semiconductor processing.

The primary conclusion is that although different techniques of trend extrapolation and variable selection will produce somewhat different results, the primary consideration is the validity of the data upon which the extrapolation is based. This implies that the major effort of a technological forecast should be directed towards obtaining data and ensuring its validity.

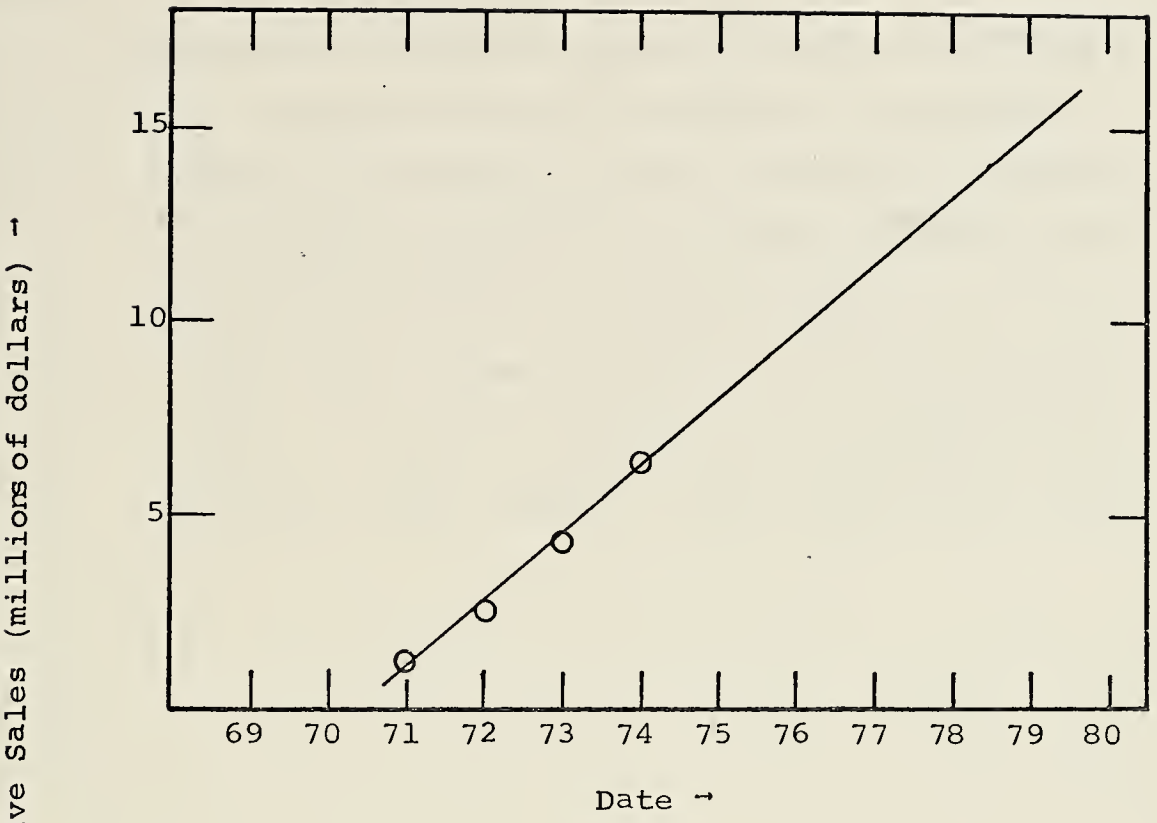

Figure 21. Cumulative Semiconductor Laser Sales (millions of dollars) Versus Date.

E. RECOMMENDATIONS

The following areas are suggested for further investigation:

1. Extend the framework of the forecast by considering the overall outlook for semiconductor laser technology as indicated by phase II and III of Table 3. The term semiconductor here should include all the various materials and pumping schemes.
2. Search patent classifications cross referenced for lasers in order to determine the expansion of semiconductor laser usage into other application areas.

APPENDIX A

LASER PATENT DATA

The following data has been extracted from the Patent Office Gazette for the period 1 January 1963 through 31 January 1974, volumes 786 through 918 inclusive. Within class 331 which designates "oscillators" the subclass number 94 designating "maser amplifier" was used for the first time in 1963, therefore this year was selected as the starting point for accumulating data. Class/subclass 330/4.3, 331/94.5 (including all alphabetical suffixes) and 332/7.51 were thoroughly searched and all patents recorded. Some patents from classes which were not thoroughly searched are listed.

SEARCH CLASS CODES

Code	Class	Subclass	Title (Class/Subclass)
A	331	94.5	oscillator, laser
B	330	4.3	amplifier, laser
C	331	94.5C	oscillator, laser
D	331	94.5D	oscillator, laser
E	204		chemistry, electrical and wave energy
F	331	94	oscillator, maser
G	331	94.5G	oscillator, laser
H	331	94.5H	oscillator, laser
I	330	4	amplifier, maser
J	331	107	oscillator, solid state
K	331	94.5K	oscillator, laser
L	331	94.5L	oscillator, laser
M	331	94.5M	oscillator, laser
N	35	25	education, war
O			not used
P	331	94.5P	oscillator, laser
Q	331	94.5PE	oscillator, laser
R			not used
S	250	199	communication system, laser
T	331	94.5T	oscillator, laser
U			not used
V			not used
W			not used
X	332	7.51	modulator, laser
Y	350	160	optics, light control by altering medium
Z	331	94.005	oscillator

TYPE LASER CODES

Code	Type Laser
AR	Laser Associated Reflectors
CD	Corona Discharge Laser
CH	Chemical Laser
DY	Dye Laser
EB	Electron Beam Laser
FL	Flame Laser
GA	Gas Laser
GD	Gas Dynamic Laser
IN	Semiconductor Laser
IO	Ion Laser
LQ	Liquid Laser
MB	Molecular Beam Laser
MD	Non-Laser Modulator
MV	Metal Vapor Laser
NS	Type not specified or insufficient information in abstract to determine type laser
OO	Optically oriented particles
OR	Organic Laser
SF	Thin Film Laser
SS	Solid State Laser
TW	Traveling Wave Laser

HOLDS PATENT CODES

Code	Company Name
AAI	Aircraft Armaments Inc.
ABO	Aktiebolaget Bofors
ACC	American Cyanamid Co.
ADK	Advanced Kinetics
ADS	Adaptive Systems
AEC	U.S. Atomic Energy Commission
AEI	Associated Electrical Industries Ltd.
AER	Aerospace Corp.
AFC	Secretary of the Air Force
AGA	AGA Aktiebolag
ALS	American Laser Systems
AIS	Agency of Industrial Science and Technology
ALC	American Laser Corp.
AMY	Secretary of the Army
ADC	American Optical Co.
ANC	ANCO Corp.
ASC	American Standard Inc.
ASD	Astro Dynamics Inc.
AVC	AVCO Corp.
BAI	Baird-Atomic, Inc.
BDX	Bendix Corp.
BLI	Baush and Lomb Inc.
BOE	Boeing Company
BRI	Britt Electronics
BSC	Basic Sciences Corp.

BTL	Bell Telephone Labs Inc.
CAL	Cornell Aeronautical Lab Inc.
CAR	Carver Corporation
CBS	Columbia Broadcasting Inc.
CDC	Control Data Corp.
CEA	Commissariat a l'Energie
CGE	Compagnie Generale D'Electricite
CIL	Compagnie Industrielle Des Lasers
CIR	California Institute Research Foundation
CLO	Control Laser-Orlando, Inc.
COC	Continental Oil Co.
CON	Conductron Corp.
COR	Corning Glass Works
CPD	Canadian Patents and Development Ltd.
CRL	Coherent Radiation Labs
CSF	CSF Compagnie General de Telegraphie
CWD	CW Radiation
CWR	Case Western Reserve University
CZS	Carl-Zeiss-Stifung DBA Carl Zeiss
DTC	Duro-Test Corp.
EAK	Eastman Kodak
EEV	English Electric Valve Co. Ltd.
EGG	Edgerton, Germeshausen and Grier, Inc.
EID	E.I. Dupont De Nemours and Co.
EII	Elton Industries
EKC	Electrokinetics Corp.
ENL	Electro Nuclear Lab-Inc.

EOS	Electro Optical Systems Inc.
FLE	Ferranti Ltd.
GDC	General Dynamics Corp.
GEC	General Electric Co.
GGA	Gulf General Atomic Inc.
GIC	General Instrument Corp.
GMC	General Motors Corp.
GSY	GTE Sylvania Inc.
GTE	General Telephone and Electric Labs, Inc.
GTI	General Telephone and Electronics Inc.
GTU	Georgetown University
HAC	Hughes Aircraft Co.
HAD	Hadron Inc.
HAZ	Hazeltine Research Inc.
HIT	Hitachi Ltd.
HMC	Her Majesty's Canadian Government
HNY	Honeywell Inc.
HOL	HOLO Beam
HPC	Hewlett Packard Co.
IBM	International Business Machine Corp.
III	Inventors and Investors Inc.
ILS	International Laser Systems
ISE	International Standard Elect. Corp.
ISK	Iskra-Zavod za Automatizijo
IUP	Institute fur Angewandte Physik der Universitat Bern
KDD	Kokusai Denshin Denwa Kabushiki Kaisha
KIC	Kollsman Inst. Corp.

KKH	Kabushiki Kaisha Hitachi Seisakusho
KOR	Korad Corp.
KTC	Kearney and Trecker Corp.
LAB	Laser Associates
LAC	Lockheed Aircraft Corp.
LDL	Laser Diode Labs
LEC	Leesona Corp.
LEI	Laboratory for Electronics Inc.
LIB	Laser Inc.
LIT	Litton Systems, Inc.
LPP	Litton Precision Products Inc.
LRC	Lansing Research Corp.
LSC	Laser Systems Corp.
LSI	Laser Sciences Inc.
LSU	Leland Stanford Junior University
MAT	Matsushita Electric Ind.
MCP	M.C.P. Electronics Ltd.
MDC	McDonnell Douglas Corp.
MEL	Melpar Inc.
MER	Meret
MIT	Massachusetts Institute of Technology
MMC	Martin Marietta Co.
MMM	Minnesota Mining and Manufacturing
MON	Monsanto
MVX	Magnavox Corp.
NAP	North American Philips Co. Inc.
NDK	Nihon Denshi Kabushiki Kaisha
NAR	North American Rockwell Corp.

NAS	NASA-National Aeronautics and Space Administration
NIP	Nippon Electric Co.
NRC	National Research Council
NRD	National Research Development Corp.
NSC	Nippon Selfoc Company
NTP	Northrup Corp.
NVY	Secretary of the Navy
OII	Owens Illinois
ORC	Orlando Research Corp.
OTI	Optics Technology, Inc.
PEK	Pek Labs Inc.
PFC	Philco Ford Corp.
PHB	Photo Bell
PHL	U.S. Phillips Corp.
PKE	Perken Elmer Corp.
PRV	Private Individual/s
PIG	Patent Treuhand-Gesellschaft fur Electrishe Gluhampen mbH
QGH	Quarzlampen Gesellschaft m.b.H.
RAY	Raytheon Company
RCA	Radio Corporation of America
RCC	RCA Limited
RCN	Research Corp.
ROI	Radio Optics Inc.
ROL	Rank Organization Ltd.
RWG	Ringsdorf-Werke GMBH
SAB	Siemens Aktiengesellschaft
SAE	Siemens Aktiengesellschaft

SAI	Sanders Associates, Inc.
SAT	Societe Anonyme de Telecommunications
SED	SEED Electronics Corp.
SEI	Semi Elements, Inc.
SHA	Siemans and Halske Aktiengesellschaft
SHI	Shiba Electric Co.
SIE	Selenia Industrie
SIN	Singer Co.
SPI	Spectro Physics, Inc.
SPR	Sperry Rand Corp.
SRL	Systems Research Labs
STI	Sensor Technology Inc.
SYL	Sylvania Electric Products
SYN	Synergetics Research Inc.
TCS	Thomson-CSF
TEX	Texas Instruments Co.
TIM	General Time Corp.
TLX	Teldix Luftfahrt-Ausrustunes
TOC	Technical Operations Inc.
TPV	Telefunken Patent Verwertungsgesells-schaft m.b.H.
TRG	TRG Inc.
TRW	TRW Inc.
TSE	Tokyo Shibaura Electric Co.
UAC	United Aircraft Corp.
UCC	Union Carbide Corp.
UOM	University of Maryland College Park
USR	USSR

VAR	Varian Associates
WEC	Westinghouse Electric Corp.
WES	Western Electric Company
WLP	Warner-Lambert Pharmaceutical Co.
WOB	Werkzegmaschinenfabrik Oerlikon-Buhrle AG
XEN	Xenon Corp.
XER	Xerox Corp.
YRD	Yissum Research Development Company of Hebrew University
ZHH	Zaiden Hojin Handotai Kenkyu Shinkokai
ZRC	Zenith Radio Corp.

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	DATE DA	DATE MO	DATE YR	NO. CLAIMS	PATENT DISCRIPTION
1	A	3,136,959	MV	RCA	12	8	60	3	OPTICAL MASER
2	A	3,140,451	SS	BTL	25	10	60	7	OPTICAL MASER DEVICE
3	A	3,215,949	SS	BTL	25	10	60	10	OPTICAL MASER USING INTERNAL REFLECTION
4	A	3,308,394	NS	AOC	2	11	60	16	OPTICAL RESONANT CAVITIES
5	A	3,229,221	SS	IBM	12	12	60	12	MASER HAVING TERMINAL LEVEL ABOVE GROUND STATE
6	A	3,149,290	GA	BTL	28	12	60	5	GAS OPTICAL MASER
7	B	3,243,715	GA	AEC	5	6	61	5	TWO-GAS MASER OF IMPROVED EFFICIENCY AND POWER
8	A	3,611,179	SS	LIT	31	7	61	10	LASER WITH CENTRAL FIBER OPTIC CORE
9	A	3,172, 56	GA	HAC	18	8	61	5	HIGHLY REPETITIVE OPTICAL MASER OPERATION
10	A	3,199, 49	SS	HAC	18	8	61	9	OPTICAL MASER SYS FOR SHORT PULSES OF EMITTED ENERGY
11	A	3,243,722	NS	BAI	28	8	61	10	FREQ CONTROL SYSTEM USING REFRACTIVE INDEX CHANGE
12	X	3,381,242	NS	KIC	28	8	61	5	CONTROLLED DENSITY/INTENSITY ELECTRONS MODULATE LSR OUTPT
13	A	3,359,404	SS	BTL	29	8	61	5	END PUMPED OPTICAL MASER
14	A	3,137,827	AR	BIL	8	9	61	7	OPTICAL MASER
15	A	3,225,306	SS	BTL	19	9	61	4	OPTICAL MASER USING ND IONS IN CA TUNGSTATE HOST LATTICE
16	A	3,179,897	NS	EGG	28	9	61	2	EXCITATION SYSTEM FOR AN OPTICAL MASER
17	F	3,255,423	AT	PRV	2	10	61	10	ATOMIC HYDROGEN MASER
18	A	3,197,715	SF	BTL	3	10	61	4	THIN FILM OPTICAL MASER
19	A	3,170,122	NS	BTL	30	10	61	6	FREQUENCY STABILIZED OPTICAL MASER
20	A	3,222,615	SS	IBM	10	10	61	4	CYLINDRICAL LASERS USING INTERNAL REFLECTION TECHNIQUES
21	A	3,229,222	SS	IBM	24	11	61	12	LASERS USING RESONATOR WITH HEAT SINK
22	A	3,256,716	SS	BTL	20	11	61	4	OPTICAL MASER COMPRISING THE ACTIVE MEDIUM CAWO4 PR
23	A	3,248,667	SS	BTL	20	11	61	7	MASER COMPRISING ACTIVE MEDIUM CAWO4 TM
24	A	3,248,668	SS	BTL	20	11	61	7	MASER COMPRISING ACTIVE MEDIUM CAWO4 HD
25	A	3,256,715	SS	BTL	20	11	61	4	OPTICAL MASER COMPRISING THE ACTIVE MEDIUM CAF2 ND
26	A	3,243,723	SS	BTL	20	11	61	12	MASER USING SINGLE CRYSTAL MOLYBDATE COMPOSITION
27	A	3,257,625	SS	BTL	20	11	61	10	OPTICAL MASER WITH SPECIFIED ACTIVE MEDIA
28	A	3,177,446	NS	UAC	12	12	61	4	MEANS FOR INCREASING POPULATION OF SEL ENERGY LEVEL
29	A	3,210,687	SS	BTL	22	12	61	8	SOLID STATE CONTINOUS WAVE OPTICAL MASER
30	A	3,144,617	GA	BTL	29	12	61	12	OPTICAL MASER WITH CONVEX NEG TEMP MEDIUM EXTREMITIES
31	A	3,202,934	SS	PRV	29	12	61	11	CATHODE RAY EXCITED LASER GENEPATOR
32	A	3,431,511	SS	LPP	8	1	62	3	OPTICAL MASER APPARATUS WITH PUMP TRIGGER
33	A	3,457,523	LQ	PHL	25	1	62	1	EUROPIUM-TPI-DIBENZOYLMETHANE LASER
34	A	3,225,307	LQ	PRV	12	2	62	5	OPTICAL MASER USING LIQUID RARE EARTH CHELATE
35	A	3,230,474	SS	PRV	16	2	62	7	SOLID STATE LASER PUMPING USING LIGHT CONDENSING SYSTEM
36	A	3,411,106	MV	QGH	19	3	62	4	MERCURY KRYPTON LASER
37	A	3,262, 71	SS	IBM	22	3	62	5	RADIENT ENERGY SOURCE EMPLOYING EXPLODING GRAPHITE ROD
38	A	3,209,281	NS	AEC	22	3	62	6	DYNAMIC PINCH PULSE MASER PUMPING
39	A	3,262, 70	NS	IBM	26	3	62	13	EXPLODING WIRE ENERGY SOURCE AND LASER EMPLOYING SAME
40	A	3,179,898	NS	BLI	2	4	62	5	ELLIPTICAL LAMINAR REFLECTING CAVITY FOR MASER EXCITATION
41	P	3,731,225	NS	SAI	2	4	62	14	FIBER OPTIC LASER SYSTEM
42	A	3,238,470	NS	BLI	5	4	62	7	LASER PUMPING USING ELLIPSOID REFLECTOR
43	A	3,315,177	SS	AMY	5	4	62	21	LASER GENERATOR
44	A	3,178,657	NS	HAC	11	4	62	3	PRODUCTION OF REPETITIVE SHORT PULSES OF COHERENT LIGHT
45	A	3,172, 57	GA	BTL	12	4	62	15	GASEOUS OPTICAL MASER
46	A	3,265,989	SS	SAB	13	4	62	9	LASER USING HI FREQ ELECTRODELESS PUMPING
47	A	3,208, 9	SS	NVY	30	4	62	6	LASER WITH YTTERBIUM ACTIVATED GLASS SENSITIVE ELEMENT
48	A	3,271,695	NS	LIT	8	5	62	5	REGENERATIVE OPTICAL PUMPING SYSTEM
49	A	3,383,621	SS	RAY	18	5	62	3	LASER CRYSTAL WITH PRISMATIC END SURFACE
50	A	3,242,439	GA	BTL	21	6	62	6	VISIBLE OUTPUT GAS MASER WITH MODE PATTERN SELECTOR

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLOS PAT	---DATE--- DA	MO	YR	NO. CLAIMS	PATENT DISCRIPTION
51	A	3,355,674	NS	IBM	27	6	62	2	OPTICAL FIBER LASER SYSTEM
52	A	3,162,822	SS	AOC	9	7	62	6	LASER PUMPING WITH PHOTOGRAPHIC FLASHBULB
53	A	3,230,475	SS	AOC	10	7	62	11	STRUCTURE FOR INCREASING LIGHT INTENSITY AT A DISTANT PT
54	A	3,271,696	NS	PRV	10	7	62	5	LASER PUMPING USING CHEMICAL CARTRIDGE
55	A	3,286,193	NS	AOC	27	7	62	15	STRUCTURE USING ENERGY DIVERTING MASKING ELEMENTS
56	A	3,281,712	NS	AOC	27	7	62	24	MODE SELECTIVE Q SWITCHING LASER STRUCTURE
57	A	3,369,192	NS	AOC	27	7	62	2	LASER CONFIGURATION
58	A	3,258,717	AR	AMY	3	8	62	9	LASER CAVITY HAVING SPHERICAL REFLECTORS
59	A	3,153,204	SS	AEI	14	8	62	11	LASER ASSEMBLY
60	A	3,414,835	NS	PRV	15	8	62	19	CLOSED PATH LASER DEVICES
61	A	3,354,405	NS	IBM	24	8	62	2	ENERGY COUPLING DEVICE
62	A	3,187,270	NS	BTL	27	8	62	3	OPTICAL MASER MODE SELECTOR
63	A	3,277,392	NS	PRV	4	9	62	7	ADJUSTABLE FEEDBACK LASER MODULATOR
64	B	3,154,751	SS	AAI	7	9	62	4	NON-RESONANT LASER CRYSTAL STRUCTURE FOR AMPLIFIER
65	A	3,210,688	AR	AOC	10	9	62	8	OPTICAL COUPLING MEANS FOR LASER
66	A	3,229,223	SS	RCA	10	9	62	7	MODULATION SYSTEM HAVING INTERNAL POLARIZATION VECTOR SEL
67	A	3,316,500	SS	SPR	11	9	62	10	SOLID STATE LASER PUMPED BY INJECTION DEVICES *******
68	A	3,196,366	SS	AOC	18	9	62	6	DOUBLE END PUMPED OPTICAL MASER USING IMMERSION OPTICS
69	F	3,263,183	AT	VAR	24	9	62	7	STORAGE CELL AND CAVITY STRUCTURE FOR ATOMIC HYDROGEN LSR
70	A	3,247,467	NS	BTL	28	9	62	4	DIFFRACTION LIMITED OPTICAL MASER
71	A	3,242,440	NS	AOC	3	10	62	20	TIME CONTROLLED OUTPUT LASER STRUCTURE
72	A	3,396,343	NS	NAP	11	10	62	6	OPTICAL MASER WITH ADJUSTING MECHANISM FOR A MIRROR
73	A	3,265,990	IN	IBM	15	10	62	13	STIMULATED EMISSION OF RADIATION IN SEMICONDUCTOR DEVICES
74	A	3,270,291	NS	RCA	22	10	62	9	LASER CONTROL DEVICE USING A SATURABLE ABSORBER
75	A	3,245, 2	IN	GEC	24	10	62	10	STIMULATED EMISSION SEMICONDUCTOR DEVICES
76	A	3,248,669	IN	IBM	30	10	62	1	SEMICONDUCTOR LASER WITH OPTICAL CAVITY
77	X	3,367,230	IN	IBM	30	10	62	10	STRESS MODULATION OF RECOMBINATION RADIATION IN SEMICOND
78	A	3,248,670	IN	IBM	30	10	62	15	SEMICONDUCTOR LASER WITH OPTICAL CAVITY
79	A	3,454,899	SS	GTE	16	11	62	4	EUROPIUM DOPED YTTRIUM OXIDE OPTICAL MASER MATERIALS
80	A	3,270,290	SS	COR	19	10	62	5	ND GLASS LASER HAVING OUTPUT AT ABOUT 9180A
81	A	3,248,671	IN	IBM	30	11	62	1	LASERS USING INTERNAL REFLECTION TECHNQIUES
82	A	3,278,858	GA	BTL	13	11	62	3	OPTICAL MASER EMPLOYING MULTIPLE GASES
83	A	3,341,787	IN	TEX	3	12	62	1	LASER SYS WITH PUMPING BY SEMICOND RADIANT DIODE
84	A	3,292,102	SS	PRV	14	12	62	4	PULSED OPTICAL BEAM GENERATOR
85	A	3,406,354	SS	CGE	17	12	62	6	CRYSTAL LASER DEVICE
86	A	3,179,899	SS	BTL	17	12	62	6	OPTICAL MASER EQUIPMENT
87	A	3,252,110	NS	HNY	27	12	62	9	LASER END MIRROR ALIGNMENT APPARATUS
88	A	3,257,626	IN	IBM	31	12	62	9	SEMICONDUCTOR LASER STRUCTURES
89	A	3,300,734	NS	PRV	7	1	63	14	PUMPING A LASER WITH AN EXPLODING WIRE
90	A	3,243,729	SS	GMC	9	1	63	7	LASER OP BY CONTROLLING REGENERATIVE ACTION
91	A	3,427,565	NS	AER	18	1	63	24	LASER ARRANGEMENT
92	A	3,297,958	SS	PRV	23	1	63	1	SOLAR PUMPED LASER
93	A	3,164,782	GA	PRV	31	1	63	1	GAS FILLED ENVELOPE FOR SOLID LASER TUBE
94	A	3,316,501	NS	BTL	1	2	63	6	OPTICAL MASER APPARATUS
95	A	3,258,718	IN	MIT	7	2	63	1	SEMICONDUCTOR INFRARED MASER
96	A	3,310,753	NS	MMC	7	2	63	15	SEQUENTIALLY FIRING ARAY OF LASER UNITS
97	I	3,525,947	SS	SAB	21	2	63	8	LSR WITH ENERGY LEVELS IAW MECHANICAL STRAIN
98	A	3,614,655	NS	PHL	22	2	63	20	MODULATION USING INTERFERENCE BET 2 PORTIONS OF OUTPUT
99	A	3,289, 99	NS	TOC	27	2	63	7	COHERENT LIGHT OSCILLATORS
100	A	3,274,512	NS	IBM	6	3	63	8	RESONATOR FOR RADIATION GENERATED BY STIMULATED EMISSION

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	---DATE--- DA	MO	YR	NO. CLAIMS	PATENT DISCRIPTION
101	A	3,164,781	SS	EGG	7	3	62	1	OPTICAL MASER PUMPING SYSTEM
102	A	3,434, 72	CO	AER	8	3	63	22	CONTINUOUS WAVE LASER ARRANGEMENT
103	A	3,464, 23	OO	AER	8	3	63	7	PULSED LASER ARRANGEMENT
104	A	3,292,103	GA	PRU	15	3	63	5	LASER IMAGE AMPLIFYING SYSTEM
105	A	3,314, 21	SS	WEC	15	3	63	6	CATHODOLUMINESCENT PUMPED LASER
106	A	3,371,287	NS	RCA	15	3	63	3	HIGH POWER LASER INCORPORATIN SELF HEALING MIRROR MEANS
107	A	3,411,105	GA	BTL	15	3	63	5	POLYATOMIC GASEOUS INFRARED OPTICAL MASER
108	A	3,403,352	NS	WEC	15	3	63	6	EFFICIENT COUPLING 8ETWEEN PHOSPHOR PUMP SCURCE AND LASER
109	A	3,432,766	NS	NRD	15	3	63	9	APPARATUS FOR PRODUCING STIMULATED EMISSION OF RADIATION
110	A	3,309,620	NS	PRV	21	3	63	14	PUMPING A LASER 8Y EXPLODING DISPERSE METAL PARTICLES
111	A	3,284,722	IN	RCA	22	3	63	10	LIGHT COUPLING DEVICE
112	A	3,277,393	NS	PRV	18	3	63	2	ADJUSTABLE FEED8ACK LASER MODULATOR
113	A	3,311,843	GA	WGH	18	3	63	5	VISIBLE HE NE LASER
114	A	3,456,209	IN	PHL	22	3	63	12	USE OF REFRACTIVE INDEX GRADIENT TO CONFINE LASER BEAM
115	B	3,421, 97	SS	AOC	25	3	63	6	LSR AMP WITH ANGULARLY DISPOSED REFLECTION RED. END SURF.
116	A	3,358,243	NS	SPR	25	3	63	6	LASER WITH INTERFEROMETER CONTROLLED OSCILLATORY MODES
117	A	3,366,892	SS	IBM	26	3	63	1	SOLID STATE LASER MODE SELECTION MEANS
118	A	3,319,182	SS	HNY	27	3	63	3	DOUBLE PUMPED LASER
119	A	3,281,713	NS	PRV	27	3	63	3	LASER Q SHARPENER
120	A	3,439,288	GA	CSF	27	3	63	17	LASER WITH RADIATION IN THE 40 MICRON 8AND
121	A	3,351,870	GA	MMC	2	4	63	8	PULSED GAS LASER
122	X	3,292,108	MD	BTL	19	4	63	3	TRAVELING WAVE COAXIAL LIGHT MODULATOR
123	A	3,354,406	IN	RCA	22	4	63	5	ELEMENT AND APPARATUS FOR GENERATING COHERENT RADIATION
124	A	3,402,364	NS	NAP	22	4	63	16	OPTICAL MASER WITH ROOF SYSTEM REFLECTOR UNDER 90 DEGREES
125	A	3,289,100	SS	BTL	25	4	63	3	NIOBATE MASER MATLS AND DEVICES MADE THEREFROM
126	A	3,478,279	GA	NIP	26	4	63	11	OPTICAL MASER
127	A	3,319,183	LQ	GTE	30	4	63	2	OPTICAL MASER CELL FOR USE WITH LIQUID MEDIA
128	A	3,467,914	GA	SAB	30	4	63	7	LASER PUMPED 8Y MONOENERGETIC ELECTRONS
129	A	3,302,127	GA	AVC	30	4	63	6	GAS LASER AND METHOD OF OPERATION
130	A	3,297,957	SS	AMY	30	4	63	14	GROOVED ACTIVE MEDIUM FOR LASER
131	A	3,283,262	NS	BTL	1	5	63	10	OPTICAL MASER OPERATING IN TM MODE
132	A	3,456,210	NS	RAY	1	5	63	3	TRAVELING WAVE SINGLE MODE LASER
133	A	3,614,653	GA	8TL	2	5	63	11	OPTICAL MASER
134	B	3,247,459	IN	PHL	3	5	63	2	PLURAL LASER AMPLIFIERS IN TANDEM
135	A	3,312,910	IN	PRV	6	5	63	3	FM MODULATION OF EMITTING PN JUNCTION
136	A	3,469,205	NS	NRD	7	5	63	17	CONTROL OF OPTICAL MASERS OF LASERS
137	A	3,308,395	NS	HAC	15	5	63	6	SPRING ENERGIZED LASER ROTATING TRIGGER
138	A	3,390,351	GA	SPI	15	5	63	7	VACUUM SEALING OF GAS LASER WINDOWS
139	A	3,461,402	NS	CGE	17	5	63	2	LSR DEFLECTOR WITH NON-UNIFORM FIELD APPLIED TO E-O XTAL
140	A	3,582,819	NS	SA8	22	5	63	11	DEVICE FOR INTERNAL MODULATION OF LASER RADIATION
141	A	3,311,844	NS	UAC	31	5	63	5	HIGH REPETITION RATE LASER SYSTEM
142	A	3,327,243	SS	PRV	3	6	63	2	LASER TUNING AND MODULATING SYS HAVING EXT FEED8ACK PATH
143	A	3,339,150	SS	RAY	3	6	63	3	LIQUID COOLED SOLID STATE LASER
144	A	3,344,365	SS	RCA	3	6	63	4	PRODUCING AN ANGULARLY ROTATA8LE 8EAM WITH NO MOVING PART
145	A	3,335,372	OR	8AI	5	6	63	6	ORGANIC LASER
146	A	3,704,427	IN	SA8	7	6	63	23	DEVICE FOR STIMULATING EMISSION OF RADIATICN FROM A DIODE
147	A	3,311,845	NS	AOC	10	6	63	6	Q SWITCHING APPARATUS FOR A LASER DEVICE
148	A	3,340,479	IN	BTL	14	6	63	2	LASER TUNABLE 8Y JUNCTION COUPLING
149	A	3,440,559	SS	EEV	17	6	63	3	KRYPTON XENON FLASH TUBE FOR PUMPING A RUBY LASER
150	A	3,311,846	SS	AOC	20	6	63	5	POLARIZING APPARATUS USING INCLINED PLATES OF LASER MATL

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	---DATE--- DA	MO	YR	NO. CLAIMS	PATENT DISCRIPTION
151	A	3,299,368	SS	UAC	24	6	63	10	LASER LIGHT GATE WITH PIEZOELECTRIC CRYSTAL
152	B	3,235,813	NS	BTL	23	6	63	5	AMPLIFIER WITH OPTIMUM SIGNAL TO NOISE RATIO
153	A	3,309,621	SS	HAC	24	6	63	3	MODE CONTROLLED LASER
154	B	3,312,905	NS	RCA	24	6	63	7	HI POWER LSR WITH PLURAL TUNABLE AMPLIFIER STAGES
155	A	3,363,195	IN	BTL	1	7	63	9	JUNCTION DIODE MASER
156	A	3,229,224	NL	TIM	3	7	63	6	APP FOR MAINT PARALLELISM AND DIST BETWEEN TWO OBJECTS
157	A	3,413,567	NS	FHC	5	7	63	8	LASER REFLECTOR AND COOLING MEANS
158	A	3,449,693	SS	CGE	10	7	63	2	CONTROL DEVICE FOR LASER OSCILLATORS
159	A	3,393,373	IN	PRV	11	7	63	2	ELECTRON STIMULATED OPTICAL MASER
160	A	3,387,226	GA	NAP	15	7	63	3	BLOCK OF INSULATING MATERIAL HAVING GAS FILLED CHANNEL
161	A	3,402,365	NS	NIP	19	7	63	5	MONOCHROMATIC OPTICAL MASER
162	A	3,445,785	SS	AOC	5	8	63	1	SOLID COMPONENTS AND LIGHT ABSORBING CLADDINGS
163	F	3,265,988	SF	BTL	13	8	63	5	SUPERCONDUCTING METALLIC FILM LASER
164	A	3,417,344	LQ	NVY	14	8	63	1	LASER USING LIQUID SOLUTION OF CHROME ALUMINUM
165	A	3,354,407	SS	ASC	21	8	63	3	PIEZO ELECTRIC MODULATION OF LASERS
166	A	3,430,158	SS	BTL	21	8	63	3	OPTICAL MASER HAVING NON PARALLEL BREWSTER SURFACES
167	A	3,449,692	NS	WEC	4	9	63	2	LASER MODULATION SYSTEMS
168	A	3,353,114	IN	BOE	9	9	63	14	TUNNEL INJECTION LIGHT EMITTING DEVICE
169	B	3,253,226	NS	BTL	16	9	63	5	OPTICAL MASER AMPLIFIER
170	A	3,395,366	NS	AOC	19	9	63	1	MODE SELECTIVE LASER STRUCTURE
171	A	3,614,654	GA	BTL	20	9	63	12	DIRECT CURRENT GASEOUS OPTICAL MASER STRUCTURE
172	A	3,497,827	GA	PHL	23	9	63	14	LSR USING NEG GLOW IN COLD CATHODE GLOW DISCHARGE TUBE
173	A	3,321,714	GA	BTL	24	9	63	6	LIGHT MODULATING SYSTEM
174	A	3,423,691	SS	GEC	25	9	63	5	DISK LASER WITH INDIRECT OPTICAL PUMPING
175	A	3,388,343	NS	BTL	30	9	63	4	OPTICAL MASER WITH REFLECTING PRISM
176	B	3,248,660	NS	EKC	2	10	63	12	OPTICAL MASER AMPLIFIER AND OSCILLATOR
177	A	3,423,692	SS	WES	7	10	63	14	COOLING A LASER CRYSTAL AND/OR PRECLUDE PREFERENTIAL LAS
178	A	3,395,367	GA	SPI	9	10	63	5	SYSTEM FOR STABILIZING THE AMPLITUDE OF A LASER OUTPUT
179	A	3,395,367	GA	PKE	9	10	63	5	RIGHTS SHARED WITH SPECTRA PHYSICS
180	A	3,423,693	SS	GEC	9	10	63	6	DISK LASER WITH DIRECT OPTICAL PUMPING
181	A	3,464, 24	GA	SPI	21	10	63	10	SELECTION AND CONTROL OF TRANSITIONS BY INHOMO FIELDS
182	A	3,412,344	IN	RCA	30	10	63	8	SEMICONDUCTOR PLASMA LASER
183	A	3,383,622	NS	AOC	4	11	63	5	END PUMPED LASER STRUCTURES EMPLOYING IMMERSION OPTICS
184	A	3,382,454	IN	RAY	12	11	63	8	LOW LOSS INJECTION LASER
185	A	3,470,490	NS	ROI	12	11	63	15	NUCLEAR RADIATION EXCITES PHOSPHOR TRANSDUCER WHICH PUMPS
186	A	3,430,159	NS	RAY	14	11	63	8	FLASHTUBE TRIGGERING CIRCUITS
187	A	3,334,314	GA	BTL	18	11	63	6	MASER USING HE3 ISOTOPE AS AUXILIARY GAS
188	A	3,373,376	NS	TRW	18	11	63	10	KERR CELL LASER MODULATOR CORRECTED FOR REFRACTIVE INDEX
189	A	3,414,836	NS	TRW	18	11	63	8	Q SWITCHED LASER
190	A	3,361,987	NS	UAC	29	11	63	3	POLY SIDED FOLDED PATH LASER
191	A	3,628,175	GA	PKE	29	11	63	13	LSR HAVING CONCENTRIC RESERVOIRS AND CYL RESONATOR
192	A	3,387,227	NS	TRW	2	12	63	28	GAS DISCHARGE LIGHT SOURCE FOR LASER PUMPING
193	A	3,528, 28	GA	NRC	4	12	63	1	GASEOUS LASER OF IMPROVED CONSTRUCTION
194	A	3,309,622	NL	MMC	9	12	63	15	SELF OSCILLATING NUCLEAR POWERED PULSING DEVICE
195	A	3,361,988	IN	BTL	9	12	63	5	LASER MATRIX DEVICE
196	A	3,451, 7	LQ	PRV	10	12	63	2	LIQUID LASER CELL
197	A	3,287,659	IN	BOE	12	12	63	13	SIGNAL GENERATOR USING SEMICNDTR MATL IN MAG AND EL FIELD
198	A	3,510,795	IN	SHA	13	12	63	19	INTEGRAL HEAT SINK IN A LASER DIODE
199	A	3,355,675	SS	BTL	16	12	63	1	LASER DEVICE USING ND PDCL3
200	A	3,414,837	SS	AOC	18	12	63	4	PLURAL FIBER OPTIC LASER CONSTRUCTION

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	DATE DA	DATE MO	DATE YR	NO. CLAIMS	PATENT DISCRIPTION
201	A	3,381,240	SS	BTL	20	12	63	4	DIVALENT METAL DOPED FLUORIDES AS OPTICAL MASER MATERIAL
202	A	3,614,657	GA	NDK	27	12	63	8	CYLINDRICAL PLASMA LASER
203	A	3,293,564	NS	IBM	30	12	63	1	CONICAL ENERGY REFLECTING COUPLING DEVICE
204	A	3,281,714	IN	IBM	31	12	63	1	INJECTION LASER USING MINORITY CARRIER TUNNELING
205	A	3,293,565	NS	IBM	31	12	63	1	LASER IMAGING EMPLOYING DEGENERATE OPTICAL CAVITY
206	A	3,496,482	SS	UCC	31	12	63	6	DEVICE USING YTTRIUM OXIDE AS HOST MATERIAL
207	A	3,448,403	SS	PRV	15	1	64	8	LSR ELEMENT CONCENTRIC WITHIN CYL LIGHT PUMP TUBE
208	B	3,317,848	IN	IBM	20	1	64	6	NON-RECIPROCAL LIGHT AMPLIFIER
209	A	3,418,598	SS	RAY	24	1	64	5	STANDING WAVE SINGLE MODE LASER
210	A	3,398,379	SS	CDC	27	1	64	7	TOTAL INTERNAL REFLECTION PROPAGATION DIRECTION SELECTION
211	A	3,365,678	SS	COR	28	1	64	6	LASER WITH PHOTOCHROMIC GLASS AS Q SPOILING MEDIUM
212	A	3,363,196	GA	PRV	29	1	64	18	GASEOUS LASER DEVICE
213	A	3,389,348	SS	UAC	7	2	64	7	GATING SYSTEM FOR HIGH POWER LASER CASCADE
214	B	3,214,702	NS	COR	10	2	64	3	TRAVELING WAVE LSR AMPLIFIER WITH GLASS FILTER
215	A	3,303,431	IN	IBM	10	2	64	9	COUPLED SEMICONDUCTOR INJECTION LASER DEVICES
216	X	3,559,101	MD	NVY	12	2	64	7	OPTICAL ISOLATOR FOR DEVICES THAT EMIT COHERENT RADIATION
217	A	3,359,507	IN	GEC	19	2	64	11	SEMICONDUCTOR JUNCTION LASER DEVICE
218	A	3,359,508	IN	GEC	19	2	64	7	HIGH POWER JUNCTION LASER STRUCTURE
219	A	3,359,509	IN	GEC	19	2	64	6	JUNCTION LASER WITH TEMPERATURE COMPENSATION
220	A	3,434, 73	AR	PFC	24	2	64	3	RAPID ACTING LASER Q-SWITCH
221	A	3,560,871	NS	HNY	27	2	64	6	FIELD RESPONSIVE ABSORBER FOR Q-SPOILING A LASER
222	A	3,496,483	NS	IBM	28	2	64	14	LASER POLARIZATION MODULATION TECHNIQUES
223	B	3,754,190	NS	PRV	2	3	64	4	SATURABLE FILTER
224	A	3,427,566	SS	UCC	2	3	64	10	LASER USING GADOLINIUM OXIDE AS THE HOST MATERIAL
225	A	3,361,989	SS	AFC	9	3	64	9	SOLID STATE OPTICAL LASER
226	A	3,493,885	SS	IBM	9	3	64	6	PHOTOBLEACHING Q-SPOILER DYE FOR LASER OPERATION
227	A	3,454,898	NS	HAC	16	3	64	6	TRIGGERING MECHANISM FOR HIGH SPEED LASER SWITCHING
228	A	3,454,900	SS	NVY	18	3	64	5	LASER PUMP WITH INTEGRAL COOLING
229	X	3,290,619	MD	BTL	19	3	64	14	CENTRO-SYMMETRIC PEROVSKITE CRYSTALS BIASED SEV PI PHASE
230	A	3,379,997	NS	PRV	19	3	64	8	MAGNETOHYDRODYNAMIC LIGHT SOURCE EXCITED LASER
231	8	3,333,206	NS	CSF	20	3	64	4	STABLE TRAVELING WAVE AMPLIFIER FOR PULSED LASERS
232	X	3,482,189	IN	GEC	24	3	64	3	FREQ CONTROL BY APPLICATION OF FORCE
233	A	3,393,374	NS	NVY	25	3	64	1	HIGH PRF LASER TRANSMITTER
234	A	3,370,253	AR	NVY	31	3	64	6	INTEGRAL MIRROR PHOTODETECTOR STRUCTURE
235	A	3,470,491	NS	AOC	31	3	64	8	BISTABLE LASER APPARATUS
236	A	3,469,206	NS	IBM	1	4	64	10	DEGENERATE LSR DEV HAVING POLARIZATION CONTROL OF LIGHT
237	A	3,409,843	NS	RAY	2	4	64	4	SINGLE MODE LASER
238	B	3,416, 89	SS	AOC	3	4	64	13	LASER AMPLIFIER CONSTRUCTION
239	A	3,484,713	IN	GEC	3	4	64	9	TWO STAGE SEMICONDUCTOR COHERENT RADIATION SOURCE
240	A	3,437,952	SS	PRV	6	4	64	1	OUTPUT CONTROL USING COUPLED ELECTRO ACOUSTIC TRANSDUCER
241	A	3,278,857	AT	VAR	6	4	64	5	ATOMIC DEVICE USING COMPOSITE VACUUM ENVELOPE AND PUMP
242	A	3,483,486	SS	IBM	10	4	64	11	MULTIPLE PHOTON LASER
243	A	3,493,889	LQ	SAE	21	4	64	5	CHEMICALLY PUMPED LASER DEVICE
244	A	3,404,349	NS	BTL	28	4	64	9	OPTICAL MASER FOR HIGHER ORDER MODES
245	A	3,407,362	GA	NVY	28	4	64	3	SHOCK WAVE PUMPED LASER
246	A	3,503, 6	SS	UCC	30	4	64	5	LSR DEVICE INCLUDING LANTHANUM OXIDE AS HOST MATERIAL
247	A	3,408,593	NS	GEC	30	4	64	11	SCANNED LASER BEAM DEVICE
248	X	3,518,574	IN	IBM	1	5	64	10	INJECTION LASER DEVICE
249	A	3,482,182	NS	IBM	1	5	64	6	CONTROLLED SYSTEMS FOR EFFECTING SELECTIVE LASING
250	A	3,418,599	NS	UCC	1	5	64	2	Q SWITCHING DYE SOLN FOR LIGHT CONTRCL OF GIANT PULSE LSR

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	DATE DA	DATE MO	DATE YR	NO. CLAIMS	PATENT DISCRIPTION
251	A	3,395,364	GA	HAC	6	5	64	6	IONIZED NOBLE GAS LASER
252	A	3,427,563	IN	IBM	13	5	64	17	MULTISTABLE DEVICE OPERATING ON PRINCIPLE OF STIM EMISSN
253	B	3,252,103	SS	BTL	14	5	64	10	ND-YAG LASER AMPLIFIER AND OSCILLATOR
254	A	3,375,464	SS	EIO	14	5	64	13	SINGLE PHASE SOLID SOLUTION LUMINESCENT COMPOSITIONS
255	A	3,464, 25	GA	SPI	25	5	64	24	GAS LASERS
256	A	3,490, 52	NS	BTL	25	5	64	16	RARE EARTH CONTAINING COMPOSITIONS AND PREP OF SAME
257	A	3,530,397	SS	KOO	1	6	64	15	PRISM SHAPED ACTIVE LASER ELEMENT
258	A	3,510,796	GA	PHL	2	6	64	3	GAS LASER HAVING CONICAL CHANNEL
259	A	3,404,350	NS	PRV	2	6	64	7	DIRECTED BEAM PORTABLE LASER SYSTEM
260	X	3,392,353	NS	BTL	11	6	64	9	MASER INTERCAVITY PHASE MODULATOR
261	A	3,440,562	NS	WLP	15	6	64	8	BISTABLE LASER STRUCTURE
262	A	3,437,953	SS	KOR	19	6	64	6	GIANT PULSE LASER CONTROL SYSTEM
263	A	3,402,367	GA	NIP	20	6	64	13	THREE ELECTRODE COLD CATHODE GAS LASER TUBE
264	A	3,361,990	NS	BTL	22	6	64	10	FREQUENCY STABILIZATION APPARATUS FOR OPTICAL MASERS
265	A	3,404,351	LQ	BTL	24	6	64	2	NEODYMIUM DOPED DEUTERIUM OXIDE LASER
266	A	3,478,277	NS	BTL	24	6	64	11	OPTICAL MODE SELECTOR
267	A	3,423,695	NS	UCC	24	6	64	3	GIANT PULSE LASER WITH DUAL Q SWITCHING
268	A	3,223,944	SS	RAY	25	6	64	1	LASER EMPLOYING ELLIPTICAL REFLECTOR CAVITY
269	A	3,440,561	NS	IBM	25	6	64	3	LASER USING ELECTRONIC LIGHT SHUTTERS
270	A	3,432,767	NS	IBM	26	6	64	8	ELECTRONIC LIGHT SHUTTERS USED FOR SWITCHING BEAM DIR
271	A	3,432,768	NS	IBM	26	6	64	14	LASER DEVICE WITH MULTIPLE FREQUENCY OUTPUTS
272	A	3,496,484	SS	PRV	29	6	64	7	OPTICAL MASER WITH OUTPUT END OF ROD EXPOSED
273	A	3,431,512	IN	UCC	29	6	64	2	JUNCTION LASER WITH CONTROLLED OUTPUT
274	A	3,436,677	NS	IBM	29	6	64	5	MAGNETO OPTIC RADIATION CONTROL AND MODULATOR
275	A	3,405,370	GA	BTL	30	6	64	5	INTERNAL OPTICAL MODULATOR
276	A	3,379,998	GA	PRV	9	7	64	5	LASER IMAGE AMPLIFYING SYSTEM
277	A	3,451, 8	NS	GGA	22	7	64	13	SHOCK WAVE OPTICALLY PUMPED LASER
278	A	3,582,821	IO	BTL	27	7	64	11	OC EXCITED ION LSR INCLUDING GAS RETURN PATH
279	B	3,386, 43	NS	BTL	31	7	64	15	DIELECTRIC WAVEGUIDE,MASER AMPLIFIER AND OSCILLATOR
280	A	3,412,345	GA	WGH	19	8	64	7	NOBLE GAS HYDROGEN LASER
281	A	3,417,345	SS	HAC	21	8	64	3	HIGH RADIANCE LASER
282	A	3,496,485	GA	SAE	24	8	64	7	HOLE BURNING EFFECT REPRESSION IN A GAS LASER
283	A	3,432,769	SS	GEC	24	8	64	6	LASER USING PENTAVALENT MN ACTIVATED CA CHLOROPHOSPHATE
284	A	3,423,694	IN	MEL	26	8	64	11	RADIANT ENERGY SOURCE
285	A	3,416, 97	NS	AOC	27	8	64	5	Q SWITCHED LASER SYSTEM
286	A	3,628,176	GA	PRV	28	8	64	12	DIRECT CURRENT GAS LASERS
287	A	3,510,797	FL	PHL	29	8	64	3	ACETYLENE FLAME LASER
288	A	3,516, 10	GA	PTG	1	9	64	3	COATED DISCHARGE TUBE TO REDUCE THE EFFECTS OF CLEAN-UP
289	A	3,725,817	NS	RCA	2	9	64	7	HIGH POWER LASER SYSTEM.
290	A	3,508,164	NS	NIP	8	9	64	5	INTERNAL MODULATION WITH BIREFRINGENCE PRISM
291	A	3,449,694	GA	SPI	9	9	64	12	GAS LASER WITH INTERNAL ELECTRODES
292	A	3,470,492	SS	UCC	9	9	64	4	REVERSIBLY BLEACHING DYE FOR USE WITH GIANT PULSE LASER
293	A	3,529,261	GA	XER	10	9	64	12	LOWER ENERGY STATE OF HALOGEN DEPLETED BY ALKALI METAL
294	A	3,493,892	GA	PHL	23	9	64	3	CW LASER WITH CONTINOUS FLOW OF WATER VAPOR THRU DFS TUBE
295	X	3,504,302	IN	GEC	24	9	64	4	FREQUENCY CONTROLLED SEMICONDUCTOR JUNCTION LASER
296	A	3,477, 36	GA	PHL	24	9	64	7	GAS LASER
297	A	3,431,513	IN	NIP	28	9	64	1	TWIN SEMICONDUCTOR LASER
298	B	3,403,348	GA	BTL	29	9	64	3	FREQUENCY SELECTIVE LASER DEVICES
299	X	3,331, 36	IN	BTL	5	10	64	3	OPTICAL WAVE MODULATORS AND ATTENUATORS
300	A	3,453,556	SS	PRV	6	10	64	3	RADAR WAVES IONIZE GAS WHICH IN TURN PUMPS LASER ROD

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	DATE DA	DATE MO	DATE YR	NO. CLAIMS	PATENT DISCRIPTION
301	A	3,426,293	GA	AOC	7	10	64	3	DIAPHRAGM TUNING OF GAS LASER
3D2	A	3,473,143	GA	PHL	7	10	64	7	COLD CATHODE GLOW DISCHARGE RING LASER
303	A	3,4D5,372	LQ	GTE	2	11	64	6	LIQUID MEDIUM WITH CHELATE OF EUROPIUM AND DIBENZOYLMETHN
3D4	A	3,374,444	SS	EID	21	10	64	6	VACANCY COMPENSATED CA ND VANADATE PHOSPHORS
3D5	A	3,471,799	SS	HAC	4	11	64	6	LONGITUDINAL MODE CONTROLLED LASER
3D6	A	3,482,183	SS	AOC	5	11	64	1	LIQUID COOLED LASER DEVICE
307	A	3,440,558	SS	HAC	12	11	64	2	HIGH REPITITION RATE LASER
3D8	A	3,432,77D	NS	SYL	16	11	64	9	PRODUCING LIGHT HAVING A SINGLE FREQUENCY
3D9	A	3,392,351	GA	BTL	2D	11	64	6	LASER USING ACTIVE VAPOR IN EQUILI8 WITH LIQUID COOLANT
310	F	3,287,660	GA	NAS	24	1	64	6	SOLID STATE CHEMICAL SOURCE FOR AMMONIA 8EAM MASER
311	A	3,375,465	SS	EID	25	11	64	11	ALKALI COMP RARE EARTH DOPED ZN OR CD BORATE PHOSPHORS
312	A	3,44D,56D	NS	I8M	25	11	64	2	APPARATUS FOR CONTROLLING THE EMISSION OF LASER LIGHT
313	A	3,458,829	SS	I8M	25	11	64	5	CONTROLLING THE AREA OF EMISSION OF LASER LIGHT
314	A	3,5DD,240	NS	NVY	3D	11	64	6	TRAVELING WAVE LSR USING TOTAL INTRNL REFLECTION RESONATR
315	A	3,484,714	SS	AOC	16	12	64	8	9D DEG POL RATOR 8ET 2 RODS TO COMP FOR THERMAL GRADIENTS
316	A	3,471,800	NS	HAC	17	12	64	1D	RESONANT REFLECTOR FOR LASER BEAM OUTPUT
317	A	3,432,771	NS	IBM	18	12	64	16	OPTICAL SCANNING TECHNIQUES
318	X	3,4D6,356	NS	SYL	21	12	64	3	OPTICAL FREQUENCY TRANSLATOR
319	A	3,651,425	SS	AMY	22	12	64	6	MULTIPLE UNIT LASER SYSTEM
320	A	3,414,838	NS	PRV	29	1D	64	7	EXPLODABLE LIGHT SOURCE AND LASER LIGHT GENERATOR
321	A	3,437,955	NS	8TL	29	12	64	4	PHASE LOCKED LASER OSCILLATOR
322	A	3,471,8D1	SS	HAC	31	12	64	5	THERMALLY CONTROLLED SOLID STATE LASER
323	A	3,551,84D	GA	8TL	18	1	65	8	PULSE CODE MODULATED OPTICAL MASER
324	B	3,273, 72	NS	AOC	18	1	65	9	LASER AMPLIFIER WITH VARIA8LE GAIN CONTROL
325	A	3,493,886	NS	PRV	19	1	65	3	LASER WITH CATHODE-LUMINESCENT PUMPING LIGHT SOURCE
326	A	3,477, 3d	GA	HII	22	1	65	4	FREON RARE GAS LASER
327	A	3,428,914	GA	SPI	25	1	65	4	PLASMA TUBE HAVING VARIA8LE CROSS SECTION AND DISCHG CURR
328	A	3,444,479	NS	SYL	2	2	65	6	PRODUCING A FREQUENCY MODULATED LASER BEAM
329	A	3,4D4,352	AR	RAY	8	2	65	9	MIRROR SUPPORTING STRUCTURE FOR LASERS
33D	A	3,445,786	NS	PFC	9	2	65	3	CRYOGENICALLY COOLED ELECTRO OPTICAL APPRATUS
331	A	3,426,294	NS	AOC	10	2	65	20	LASER Q SWITCHING
332	A	3,523,256	GA	XER	12	2	65	3	HEAT PUMPED LASER
333	A	3,428,915	AR	RAY	15	2	65	13	MIRROR SUPPORTING STRUCTURE FOR LASERS
334	A	3,396,344	IN	NRD	18	2	65	1D	SEMICONDUCTOR LASER ARRAY
335	A	3,395,365	GA	BTL	24	2	65	11	FREQUENCY STA8ILIZED OPTICAL MASER
336	A	3,4D2,366	IN	I8M	26	2	65	9	8EAM SCANNING IN INJECTION LASERS
337	A	3,399,359	SS	HAC	1	3	65	18	SOLID STATE LASER
338	A	3,480,876	SS	CGE	12	3	65	7	LASER CONTROL APPARATUS
339	A	3,531,734	IO	8TL	15	3	65	2	LSR HAVING METAL CYLINDERS TO CONFINE THE DISCHARGE
34D	A	3,453,557	GA	LIB	15	3	65	11	LASER STA8ILIZATION APPARATUS
341	8	3,435,363	GA	8TL	23	3	65	9	SELF-FOCUSING LASER
342	B	3,265,977	SS	BTL	25	3	65	8	CYCLOTRON RESONANCE LASER
343	A	3,512,1D4	SS	WEC	29	3	65	4	SELECTIVE A8SORBER 8ET ACTIVE ELEMENTS REDUCES TRANS GAIN
344	A	3,437,954	NS	BTL	31	3	65	10	OPTICAL DELAY LINE DEVICES
345	A	3,4D3,353	GA	BTL	8	4	65	7	LASER HAVING SECOND CATHODE FOR SPACE CHARGE NEUTRALIZATN
346	X	3,4D7,364	NS	BTL	9	4	65	7	INTRACAVITY LASER PHASE MODULATOR
347	A	3,538,452	NS	OTI	12	4	65	5	LASER SWITCHING DEVICE APPLIED TO FI8ER OPTICS
348	A	3,394,32D	GA	PRV	20	4	65	5	GAS LASERS WITH IMPROVEX CAPILLARY TU8E
349	A	3,452,296	NS	AFC	20	4	65	2	MEANS FOR HIGH POWER DENSITY AT GIVEN RECEPTION POINT
350	A	3,4B6,129	NS	CGE	20	4	65	9	CONTROLLED RELEASE OF A PLURALITY OF LASERS

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	---DATE--- DA	MO	YR	NO. CLAIMS	PATENT DISCRIPTION
351	8	3,530,388	NS	WEC	21	4	65	11	LIGHT AMPLIFIER SYSTEM USING INTERFEROMETER SYSTEM
352	A	3,467,916	SS	WEC	25	4	65	5	SLOTTED OPTICAL MASER ACTIVE ELEMENT
353	A	3,500,230	NS	NVY	30	4	65	1	LIQUID 8LEACHABLE FILTER FOR Q-SPOILING A LASER CAVITY
354	A	3,560,872	SS	RWG	7	5	65	17	OPTICAL SOLID 8ODY LIGHT AMPLIFIER
355	A	3,487,331	SS	NRD	13	5	65	10	Q-SWITCHED LASER LIGHT SOURCES
356	A	3,462,707	SS	BTL	25	5	65	3	ND AND Y8 DOPED 8DRATE LASER GLASS
357	B	3,436,665	NS	BTL	28	5	65	6	MULTIPLE PASS OPTICAL CELL FOR LASER AMPLIFIER
358	A	3,437,951	NS	RCA	28	5	65	4	MODULATING CR Q SWITCHING A LASER
359	A	3,464, 26	SS	HAC	1	6	65	6	LASER USING PORC PRISM END REFLECTORS
360	X	3,493,845	MV	MEL	4	6	65	18	LSR USING MICROWAVE PUMPING
361	A	3,430,160	NS	AFC	11	6	65	4	LASER DIGITAL DEVICE
362	A	3,414,839	NS	BTL	18	6	65	8	UNIDIRECTIONAL RING LASER
363	A	3,488,606	NS	BTL	18	6	65	6	UNIDIRECTIONAL RING LASER
364	A	3,413,568	GA	BTL	22	6	65	6	REVERSED AXIAL MAGNETIC FIELDS IN LASERS
365	B	3,302,120	NS	BTL	23	6	65	5	LO NOISE AMP WITH PLURAL SECT 8ET CONFOCAL FOCUSERS
366	A	3,504,299	NS	BTL	23	6	65	3	OPTICAL MASER MODE SELECTOR
367	A	3,443,243	GA	BTL	23	6	65	5	FREQUENCY SELECTIVE LASER
368	A	3,543,183	NS	RWG	23	6	65	9	DEVELOPMENT OF A COHERENT MONOCHROMATIC LIGHT BEAM
369	A	3,504,298	NS	WEC	24	6	65	9	CATHODOLUMINESCENT LASER PUMP
370	A	3,469,207	GA	VAR	24	6	65	10	METAL-CERAMIC GAS LASER DISCHARGE TU8E
371	A	3,447, 97	SS	RCA	28	6	65	9	LASER USING SINGLE CRYSTAL SUCH AS DOPED CA FLUORIDE
372	A	3,500,231	SS	GEC	29	6	65	3	BREWSTER ORIENTED END PUMPED MULTIPLE DISK LASER DEVICE
373	A	3,628,177	GA	RCA	29	6	65	8	OPTICAL MODULATION SYSTEM
374	A	3,487,330	SS	NAR	30	6	65	4	HIGH POWER DISSIPATION STRUCTURE
375	8	3,327,232	NS	GEC	2	7	65	11	REFLECTIONLESS INPUT RESONANT LASER AMPLIFIER
376	A	3,476,278	SS	PRV	6	7	65	11	DIRECTED 8EAM PORTA8LE LASER SYSTEM WITH SELF CHG PWR SUP
377	A	3,439,289	IN	AFC	8	7	65	1	SEMICONDUCTOR LASER COMPONENTS FOR DIGITAL LOGIC
378	A	3,356,966	NS	AOC	12	7	65	6	LASER COOLING APPARATUS
379	A	3,524,144	NS	AMY	13	7	65	4	SHOCK INDUCED NARROW 8AND ILLUMINATOR
380	A	3,514,714	GA	UAC	16	7	65	3	AXIAL AND TRANS MAG FIELDS CONNECTED IN PUSH-PULL ARRNGMT
381	A	3,368, 87	IN	MIT	16	7	65	1	OPTICALLY PUMPED SEMICONDUCTOR LASER
382	A	3,517,327	NS	NAR	19	7	65	17	LASER OUTPUT COUPLER
383	A	3,436,678	GA	SPR	19	7	65	9	LASER CAPA8LE OF CONTINOUS FREQUENCY TUNING
384	A	3,454,901	LQ	GTE	19	7	65	3	MASER CONTAINING SOLN HAVING FORMULA GIVEN
385	A	3,482,184	NS	SPR	19	7	65	5	MULTIPLE CAVITIES SHARE COMMON LASING MATERIAL
386	A	3,422,370	NS	SPR	19	7	65	4	VARIA8LE FREQUENCY LASER
387	A	3,529,262	GA	PHL	28	7	65	6	DISCHARGE GAS INCLUDING CO2, NITROGEN AND WATER VAPOR
388	A	3,493,890	SS	BTL	28	7	65	14	PHONON TERMINATED LASER
389	A	3,500,233	GA	PFC	29	7	65	8	FREQ MODULATED LASER DEVICE
390	A	3,493,891	IN	IBM	2	8	65	2	AVALANCHE 8REAKDOWN SEMICONDUCTOR LASER
391	X	3,373,380	NS	ZRC	3	8	65	11	LSR 8EAM-SOUNDWAVE TECHNIQUES USING CURVED ACOUSTIC WAVES
392	X	3,383,627	NS	ZRC	3	8	65	8	WAVE SELECTOR WITH TAPERED ACOUSTIC TRANSDUCER
393	B	3,307,113	SS	NVY	10	8	65	2	MULTIPASS NONREGENERATING LASER AMPLIFIER CYRSTAL
394	X	3,401,357	IN	BTL	11	8	65	8	ELECTROMAGNETIC WAVE AMP,OSCILLATOR AND MODULATOR
395	A	3,417,346	NS	HAC	13	8	65	9	LASER WITH RAMAN ACTIVE MATL FOR DOU8LE QUANTUM ABSORPTN
396	A	3,564,452	GA	SPI	23	8	65	6	LASER WITH STABLE RESONATOR
397	A	3,453,558	SS	AEC	7	9	65	5	OPTICAL MASER SYSTEM PUMPED 8Y EXPLOSIVE ELEMENT
398	A	3,509,487	GA	PHL	9	9	65	3	GAS LASER WITH TRANSVERSE MAGNETIC FIELD
399	A	3,464, 27	SS	UAC	14	9	65	9	LASER MODULATION 8Y FOCUSED ACOUSTIC ENERGY
400	A	3,492,599	GA	BTL	17	9	65	11	MODE LOCKED LASER PULSE GENERATOR

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	DATE DA	DATE MO	DATE YR	NO. CLAIMS	PATENT DISCRIPTION
401	A	3,492,600	NS	BTL	17	9	65	10	OPTICAL SWITCHES AND MEMORY ELEMENTS USING COMPETING TRAN
402	A	3,477, 37	LQ	EII	24	9	65	4	LASER DEVICE EMPLOYING FLUID MATERIAL
403	A	3,462,706	NS	EAK	27	9	65	5	SATURABLE ABSORBER LASER Q-SWITCH
404	A	3,414,840	NS	BTL	28	9	65	4	SYNCHRONIZATION OF POWER SOURCES
405	A	3,427,564	GA	EOS	29	9	65	B	HIGH POWER IONIZED GAS LASER STRUCTURE
406	A	3,484,716	IN	GEC	1	10	65	B	HIGH DUTY CYCLE LASER DEVICE
407	A	3,501,713	GA	PHL	7	10	65	4	A DETUNING DEVICE FOR MOUNTING A REFLECTOR ONTO A CAVITY
408	A	3,517,329	GA	PHL	8	10	65	4	LASER HAVING ELECTROSTRICTIVE DETUNING MEMBER
409	A	3,466,569	SS	GEC	10	10	65	1	DISK LASER DEVICE
410	A	3,467,915	SS	NIP	13	10	65	1	LASER DEVICE OF INTERNAL MODULATION TYPE
411	B	3,484,710	SS	AOC	18	10	65	12	AMPLIFY LO-LEVEL VISIBLE LIGHT USING OPTICAL FIBER
412	A	3,483,4B0	IN	NIP	19	10	65	4	SEMICONDUCTOR COMPOUND LASERS
413	A	3,504,296	SS	PRV	20	10	65	14	LIGHT SYNCHROTRON USING CIRCULAR AND STRAIGHT RODS JOINED
414	A	3,525, 53	SS	GEC	22	10	65	3	TRANSVERSE MODE DISCRIMINATOR FOR LASER APPARATUS
415	A	3,517,32B	GA	NAS	24	10	65	12	STABILIZING A GASEOUS OPTICAL MASER
416	A	3,509,4B6	GA	BTL	28	10	65	7	LSR USING CARBON DISULFIDE AND NITROGEN
417	A	3,546,622	NS	LAC	29	10	65	5	LASER HAVING CONTROLLED FREQUENCY TRANSLATION
418	A	3,473,144	SS	AOC	1	11	65	15	LASER APPARATUS AND GLASS COMPOSITION
419	A	3,537, 30	GA	SAT	4	11	65	14	MEANS FOR INDICATING OPTIMUM DISCHARGE CONDITIONS
420	A	3,437,950	IO	EOS	12	11	65	7	METAL TUBE SHRINK FITTED ONTO CERAMIC DISCHARGE TUBE
421	A	3,464, 2B	GA	PKE	15	11	65	3	10.6 MICRON CO2 LASER WITH HELIUM ADDED
422	A	3,508,165	SS	PRV	17	11	65	2	CLADDINGS FOR LASERS
423	X	3,768, 37	IN	HIT	26	11	65	B	SEMICONDUCTOR DIODE LASER DEVICE
424	A	3,614,663	NS	NAR	26	11	65	B	BLACK-BODY PUMPED LASER
425	A	3,353,115	SS	HAC	29	11	65	2	RUBY LASER SYSTEMS
426	A	3,4B0,B75	NS	IBM	6	12	65	7	LASER SCANNING DEVICE WITH 2 LENS SYS AND COMM FOCAL PLN
427	A	3,435,370	NS	IBM	16	12	65	B	HIGH SPEED LASER FREQUENCY SELECTOR
428	A	3,435,371	NS	BTL	17	12	65	9	LASER MODE SELECTION APPARATUS
429	A	3,978,409	GA	LIT	17	12	65	14	DEFLECTABLE LIGHT MASER
430	A	3,448,404	NS	BTL	22	12	65	2	NONTRANSLATING VARIABLE OUTPUT COUPLER FOR OPTICAL MASERS
431	A	3,466,565	NS	BTL	2B	12	65	17	LASER MODE SELECTION
432	A	3,541,46B	NS	MMC	3	1	66	17	LSR UNITS RADIALLY DISPOSED AROUND ROTATING MULTI REFLCTR
433	A	3,424,997	GA	SPI	5	1	66	11	GAS LASER WITH GAS STORAGE ELECTRODE
434	A	3,339,151	NS	IBM	12	1	66	B	BEAM DEFLECTING LASERS
435	A	3,435,372	SS	UAC	19	1	66	B	ULTRASONIC MODULATOR HAVING A CYLINDRICAL TRANSDUCER
436	A	3,435,373	SS	BTL	21	1	66	5	TUNABLE RAMAN LASER USING CRYSTAL OF SEMICONDUCTIVE MATL
437	A	3,562,662	GA	PRV	1	2	66	7	LASER USING COLLISION DEPOPULATION
438	A	3,447, 98	GA	PRV	8	2	66	1	GAS LASER TUBE SYSTEM
439	A	3,539,939	NS	BTL	9	2	66	4	PULS GENERATOR USING ROTATING PRISM ALT REF AND TRANS
440	A	3,484,717	NS	AMY	16	2	66	4	TORSION PENDULUM Q-SWITCH FOR OPTICAL MASERS
441	A	3,448,405	IN	BTL	17	2	66	7	SCANNING LASER
442	A	3,466,566	GA	BTL	17	2	66	3	OPTICAL RESONATOR FOR LASERS
443	A	3,483,4B1	NS	WEC	2	3	66	5	RADIATION SOURCE FOR PRODUCING CW COHERENT RADIATIONS
444	A	3,451, 9	NS	RCA	4	3	66	16	LASER USING OCTACOORDINATE CHELATE COMPOUNDS
445	A	3,436,679	IN	GEC	7	3	66	20	LASER WITH ELECTRONICALLY DISPLACEABLE AND DEFLECTBL BEAM
446	A	3,518,56B	SS	PRV	11	3	66	2	XTALS INSIDE HOUSING CONTAINING IONIZABLE GAS
447	A	3,530,39B	SS	SPR	14	3	66	12	RAPID ON-OFF SWITCHING OF A CW LASER SOURCE
448	A	3,479,620	NS	BTL	16	3	66	7	LASER WITH SERIALLY COUPLED MODE SELECTING RESONATOR SCTN
449	A	3,548,337	NS	NRD	16	3	66	3	RAPID ILLUMINATION OF FIXED POINT BY ROTATING PRISM
450	A	3,553,603	GA	AVC	21	3	66	16	LSR USING ELECTRIC FIELD ACROSS A NONRESONANT OPTICAL CAV

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	DATE DA	DATE MO	DATE YR	NO. CLAIMS	PATENT DISCRIPTION
451	A	3,526,850	SS	BTL	23	3	66	1	SATURATING MAGNETIC APPLY TO HOST MAIL MODULATES LSR BEAM
452	A	3,480,877	SS	BTL	23	3	66	8	SOLID STATE LASER
453	A	3,624,544	NS	UAC	23	3	66	5	SELF MODE LOCKING OF LASERS USING DYES
454	A	3,495,185	NS	BTL	31	3	66	3	FREQ STABILIZATION APPARATUS
455	A	3,500,232	SS	BTL	1	4	66	9	SOLID STATE LASER CAPABLE OF ROOM TEMP CW OPERATION
456	A	3,405,371	SS	BTL	1	4	66	7	FLDURESCENT GARNET COMPOSITIONS AND LASERS USING SAME
457	A	3,453,559	NS	SPR	1	4	66	8	MULTIPLE LASER AMPLIFIER PHASE CONTROL SYSTEM
458	A	3,504,297	GA	BTL	4	4	66	6	BROAD BAND MASER DEVICE
459	A	3,448,406	NS	SPR	5	4	66	6	LASER FLUID FLOW SENSOR INSENSITIVE TO ROTATION
460	A	3,484,720	MV	TRG	8	4	66	12	IONIZED ALKALINE EARTH METAL LASER WITH CYCLIC EXCITATION
461	A	3,303,432	IN	GEC	18	4	66	17	HIGH POWER SEMICONDUCTOR LASER DEVICES
462	A	3,440,563	NS	SPI	19	4	66	7	KINEMATIC MOUNTING STRUCTURE FOR LASER RESONATOR
463	A	3,484,715	NS	SPI	21	4	66	9	TEMPERATURE COMPENSATING MOUNTING FOR LASER REFLECTORS
464	A	3,516, 12	GA	PKE	22	4	66	10	ARGON LASER
465	A	3,475,697	SS	HAC	26	4	66	10	LASER EMPLOYING SEMIELLIPTICAL PUMP CAVITY
466	A	3,487,329	NS	RCA	28	4	66	6	LASER COLOR CONTROL
467	A	3,496,486	GA	ISE	5	5	66	6	CONCENTRICALLY ARRANGED HYPERBOLDIDAL TUBE SECTIONS
468	A	3,483,482	SS	NVY	9	5	66	8	ONCALL SWITCHING SYSTEM FOR LASER
469	A	3,317,853	GA	CIR	12	5	66	5	GASEOUS LASERS
470	A	3,444,478	NS	NAR	12	5	66	10	BLEACHABLE REFLECTANCE OUTPUT COUPLER
471	A	3,349,339	NS	DTC	23	5	66	12	OPTICALLY PUMPED LASER USING CATHODOLUMINESCENT SOURCE
472	A	3,484,718	GA	KTC	26	5	66	8	STABILIZED LASER STRUCTURE
473	A	3,484,719	NS	BTL	27	5	66	2	STABILIZED SINGLE MODE LASER
474	A	3,522,551	GA	RCA	31	5	66	5	LONG LIFE LASER TUBE CONSTRUCTION
475	A	3,493,888	SS	UCC	7	6	66	12	LASER CRYSTAL SUPPORTING MEANS AND COOLING SYSTEM
476	A	3,456,211	SS	AOC	16	6	66	10	FIBER LASER STRUCTURES
477	A	3,473,145	SS	LEI	21	6	66	9	TUNING FORK SHAPE LASER ACTS AS OWN Q-SWITCH
478	B	3,403,349	SS	WEC	28	6	66	15	OPT PUMPED LSR AND SOLID STATE LIGHT SOURCE
479	A	3,493,893	NS	PRV	28	6	66	5	HIGH ENERGY LASER SYSTEM USING AT LEAST TWO LASERS
480	A	3,531,735	IN	GEC	28	6	66	4	GROOVES TO PREVENT RADIATION TRANSVERSE TO OPTIC AXIS
481	X	3,551,848	IN	GIC	30	6	66	3	LASER MODULATING SYSTEM
482	A	3,496,487	NS	UCC	5	7	66	13	ADDITION OF LASER BEAMS IN MULTIPLE LASER SYSTEMS
483	A	3,500,234	SS	RCA	7	7	66	3	UNITARY Q-SWITCH LASER DEVICE
484	A	3,487,332	SS	UCC	7	7	66	8	METHOD AND MEANS FOR HEAT SINKING LASER RODS TECHNIQUES
485	B	3,365,671	NS	BTL	12	7	66	9	MULT-PASS MOLECULAR LSR AMP WITH MASKING TO STOP OSCILLTN
486	A	3,465,358	GA	BTL	21	7	66	10	Q-SWITCHED MOLECULAR LASER
487	A	3,524,145	NS	GTI	29	7	66	11	BEAM DEFLECTION APPARATUS
488	A	3,445,787	NS	HAC	1	8	66	5	TUNABLE FREQUENCY STABILIZED LASER
489	A	3,466,567	GA	TRW	1	8	66	6	ELECTROSTATIC GAS BYPASS FOR ION LASERS WITH HOT CATHODES
490	A	3,492,597	GA	TRW	1	8	66	1	CERAMIC TUBE FOR GAS ION LASER
491	B	3,421, 96	SS	AOC	3	8	66	3	ELONGATED FIBER LASER AMPLIFIER COMPONENT
492	A	3,452,295	GA	VAR	4	8	66	7	DISCHARGE TUBE HAVING INSULATOR SHIELDS
493	X	3,453,561	NS	BTL	8	8	66	10	DEVICES USING CRYSTALS OF P83-MG-N82-09
494	A	3,701, 47	IN	RCA	16	8	66	3	SEMICONDUCTOR DEVICE WITH LIGHT REFLECT METALLIC LAYERS
495	A	3,500,239	GA	CGE	19	8	66	10	HEAD FOR GASEOUS FLUX MOLECULAR LASER
496	A	3,496,489	GA	AVC	22	8	66	15	GAS LASER AND METHOD OF OPERATION
497	A	3,505,613	SS	MMM	22	8	66	13	ZINC OXIDE LASER
498	A	3,487,333	GA	CAL	25	8	66	5	LASER ACTION BY CONVECTIVE FLUID MECHANICAL
499	A	3,530,400	NS	MIT	30	8	66	9	ACOLSTICALLY MODULATED LASER
500	A	3,538,454	NS	IUP	7	9	66	1	LASER EXCITATION

LIST OF LASER PATENTS IN GROER OF OATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUM8ER	TYPE LASER	HOLOS PAT	---DATE--- DA	MO	YR	NO. CLAIMS	PATENT DISCRIPTION
501	8	3,614,042	GA	UOM	14	9	66	10	COLO CATHOOE GAS LASER WITH CATHODE LIFE OVER 10,000 HRS
502	A	3,528, 29	NS	SPR	20	9	66	3	RING LSR HAVING SYCHRONIZEO PHASE MODULATORS
503	A	3,486,878	NS	SPR	20	9	66	4	RING LASER WITH MEANS FOR REOUCING COUPLING TO BACKSKTR
504	A	3,486,130	NS	SPR	20	9	66	7	RING LASER
505	A	3,500,235	GA	8TL	22	9	66	1	Q-SWITCHED MOLECULAR LASER
506	A	3,566,302	NS	SPI	23	9	66	12	LASER OPTICAL CAVITY ANO ALIGNMENT METHOO
507	A	3,492,596	NS	CAL	30	9	66	5	LASER SCANNER
508	A	3,504,300	SS	WEC	3	10	66	5	FLUCRAPATITE LASER MATERIAL DOPEO WITH NC AND MANGANESE
509	A	3,466,568	LQ	GTE	3	10	66	13	LIQUID LASER
510	A	3,585,522	NS	WEC	3	10	66	5	CYLINDRICAL LIGHT EMITTER
511	A	3,503, 4	NS	PHL	4	10	66	5	FLUID CONTROLLA8LE 8ELLOWS FOR VARYING CAVITY LENGTH
512	A	3,496,488	NS	8TL	5	10	66	5	FREQUENCY STABILIZED OPTICAL MASEP
513	A	3,491,309	GA	LSC	5	10	66	14	PULSEO CO2 LASER WITH WITH HI VOLT GRADIENT AND HI GAS PR
514	A	3,564,451	NS	HIT	11	10	66	5	PIVOTALLY AOJUSTABLE Q-SWITCHED LASER
515	X	3,478,280	IN	GEC	14	10	66	7	PULSE WIOTH MODULATED LASER
516	A	3,530,401	NS	WEC	17	10	66	31	LASER SCANNING SYSTEM
517	B	3,397,362	SS	AMY	18	10	66	4	LSR CRYSTAL WITH ONE ENO SHAPED LIKE PARA8CLOID
518	A	3,537, 31	NS	PRV	18	10	66	3	PUMPING BY EXPLODING CONOUCTORS EMBEODEO IN SOLID DIELTRC
519	A	3,458,830	GA	NVY	18	10	66	10	TRANSMISSION LINE GAS LASER
520	A	3,470,493	NS	NVY	18	10	66	11	PUMP WHICH USES AN EXTENSION OF COAX TRANSMISSION LINE
521	A	3,521,188	NS	HAC	19	10	66	10	DOUBLE Q-SWITCHEO LSR WITH INTRACAVITY LOSS MODULATOR
522	A	3,560,874	NS	8TL	22	10	66	6	VARIA8LE OPTICAL FREQUENCY SHIFTER
523	A	3,470,494	GA	TRW	25	10	66	4	PULSEO LASER
524	A	3,482,185	SS	AFC	25	10	66	8	LOW IMPEDANCE THERMAL JOINT
525	B	3,395,356	SS	AOC	26	10	66	5	LASER AMPLIFIER OEVICE - REDUCES REFRACTORY TIME
526	A	3,510,799	IN	KOO	27	10	66	5	LASER ELEMENT WHICH PERFORMS LOGICAL OPERATIONS
527	A	3,500,236	NS	XER	28	10	66	9	LASER STABILIZING SYSTEM
528	A	3,548,336	SS	UCC	28	10	66	1	PRODUCING CW RAO BY PUMPING WITH HI INTENSITY ARC
529	A	3,454,897	SS	PRV	7	11	66	10	RIGHT CYLINDRICAL LASER WITH CENTER EMISSION
530	A	3,539,940	NS	NVY	8	11	66	3	LIGHT AMPLIFIER WITH UNIDIRECTIONAL CHARACTERISTICS
531	A	3,460, 53	GA	AFC	8	11	66	2	MEANS FOR PRODUCING LONG GAS OISCHARGES
532	A	3,517,330	GA	PFC	9	11	66	5	FREQ STA8 BY COMPARING AMPS OF TWO 8EAT NOTE SIGNALS
533	A	3,423,696	SS	GEC	10	11	66	5	DISK LASER WITH OIRECT OPTICAL PUMPING
534	A	3,423,697	SS	GEC	10	11	66	15	DISK LASER WITH DIRECT OPTICAL PUMPING
535	A	3,555,449	SS	WEC	15	11	66	11	LIQUIO COOLED LASER SYSTEM
536	A	3,517,331	NS	CPD	16	11	66	5	STABILIZATION OF LASERS, ETALONS AND SIMILAR OPTICAL DEV
537	A	3,517,332	NS	UAC	16	11	66	6	ACOUSTIC CELL USEO FOR FREQUENCY MOOULATION
538	A	3,479,612	NS	8TL	18	11	66	4	MOOE CONTROL IN HI PWR LSR 8Y MEANS OF LOW PWR LASER
539	X	3,462,712	NS	BTL	23	11	66	5	THIN FILM OPTICAL MOOULATOR OIODE ******
540	A	3,646,471	SS	PRV	25	11	66	2	PUMPING 8Y CYLINDRICAL ARRAY OF EXPLODING CONOUCTORS
541	A	3,546,623	NS	PRV	25	11	66	3	EXPLODING WIRE LIGHT GENERATOR USING TRANSPARENX PROJECTL
542	A	3,538,453	NS	PRV	28	11	66	5	FRUSTRATEO TOTAL INTERNAL REFLECTION LASER SYSTEM
543	A	3,462,708	NS	SPR	29	11	66	8	RING LSR HAVING EXTERNAL PIEZOELECTRIC REFLECTOR
544	B	3,516, 1	SS	AOC	1	12	66	4	THIN FI8ER LSR LIGHT AMP STRUCTURE IWTH TRIPLE CLADDING
545	B	3,437,942	SS	UCC	7	12	66	4	APPARATUS FOR INCREASING THE RADIANCE OF LASERS
546	A	3,504,295	SS	NVY	15	12	66	7	OPTICALLY CLAD LASER
547	A	3,513,409	NS	UAC	15	12	66	5	Q-SPOILING OF LASERS USING TWO OYE CELLS
548	A	3,493,887	NS	TRW	16	12	66	9	LSR CAVITY FOR OEFLECTING 8EAM PARALLEL TO ITS AXIS
549	A	3,395,368	NS	WLP	21	12	66	5	FRUSTO CONICAL LASER CONFIGURATION
550	A	3,506,927	NS	TRW	23	12	66	6	SELECTEO MOOE GIANT PULSE LASER

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	DATE DA	DATE MO	DATE YR	NO. CLAIMS	PATENT DISCRIPTION
551	A	3,534,287	LQ	GTI	23	12	66	8	LIQUID LASER ACTIVE MEDIUM
552	A	3,577, 95	SS	HAC	28	12	66	5	SEMIELLIPTICAL PUMP CAVITY
553	X	3,483,487	IN	BTL	29	12	66	8	STRESS MODULATION OF RAD WITH WIDE FREQ TUNING RANGE
554	A	3,521,189	SS	NVY	3	1	67	5	SYNCHRONOUS FACE PUMPED MULT DISK HIGH POWER LASER DESIGN
555	A	3,497,826	NS	ZRC	11	1	67	8	SCANNING LASER SYSTEMS AND COMPONENTS USEFUL THEREIN
556	A	3,500,237	NS	I8M	13	1	67	4	MODE COUPLING LASER APPARATUS
557	A	3,509,488	NS	I8M	13	1	67	9	MULTIPATH CONJUGATE LASER
558	A	3,506,928	NS	ZRC	25	1	67	5	RADIATION SCANNING APPARATUS
559	A	3,546,620	SS	NVY	26	1	67	3	SCANNING FA8RY-PEROT LASER Q-SWITCH
560	A	3,551,841	SF	PHL	30	1	67	4	THIN FILM LSR EMPLOYING AN OPTICAL CAVITY
561	A	3,617,927	NS	PRV	31	1	67	9	GENERATING GIANT PULSES BY CONTROLLING Q-FACTOR
562	A	3,534,290	IN	GEC	1	2	67	10	8EACON FOR ROTATING AN OUTPUT BEAM
563	A	3,543,179	GD	AVC	1	2	67	13	NITROGEN LASER ACTION WITH SUPERSONIC FLOW
564	A	3,471,802	NS	7EX	1	2	67	6	MONULATED LSR USING BIREFRINGENT CORE SOLIC F-P ETALON
565	A	3,534,289	NS	XER	6	2	67	11	LASER SYSTEM WITH OPTICAL DISCRIMINATOR
566	A	3,594,659	GA	IUP	8	2	67	3	FREQUENCY STABILIZATION OF GAS LASER OSCILLATOR
567	A	3,533, 12	NS	OTI	10	2	67	1	LASER APPARATUS AND METHOD OF ALIGNING SAME
568	B	3,424,991	SS	GEC	13	2	67	7	SEPARATED MIRROR FACE-PUMPED DISC LASER DEVIES
569	X	3,506,929	NS	8TL	13	2	67	12	LITHIUM TANTALATE ELECTRO-OPTICA MODULATOR
570	A	3,548,338	GA	SHI	21	2	67	4	GAS LASER NOISE REDUCTION
571	B	3,452,286	NS	ZRC	23	2	67	6	IMAGING APPARATUS
572	A	3,500,238	SS	AOC	6	3	67	2	LASER ROD AND FLASH TU8E EM8EDDED IN CLADDING GLASS
573	A	3,576,501	IN	IJP	7	3	67	3	LSR HAVING ROUGHENED N-ZONE JUST 8ELOW THE JUNCTION
574	A	3,451, 10	SS	HAC	10	3	67	3	THREE LEVEL RU8Y LASER USING OPTICAL 8ROAD8AND PUMPING
575	A	3,501,714	GA	PKE	13	3	67	13	DC EXCITED GAS LASER TU8E WITH CONDUCTIVE SIDEWALLS
576	B	3,506,925	IN	SA8	14	3	67	24	GENERATING AND AMPLIFYING ULTRA HI-FREQ SIGNALS
577	A	3,541,470	DY	IBM	20	3	67	9	DYE LASER
578	A	3,533, 13	SE	EII	23	3	67	5	LASER MATL ENCLOSED IN EXTERIOR SILVERED GENERATOR
579	A	3,479,614	IN	8TL	23	3	67	3	TUNABLE SEMICONDUCTOR MASERS
580	A	3,571,744	NS	TRW	23	3	67	8	LASERS INCORPORATING TIME VARIA8LE REFLECTIVITY
581	X	3,555,457	SS	AMY	27	3	67	1	MODULATION BY SUBJECTING ROD TO TRANS FORCED VI8RATION
582	X	3,524,147	MD	UCC	29	3	67	6	ELECTRO-OPTIC CONTROL AND MODULATION OF LIGHT
583	A	3,568, 88	GA	CGE	31	3	67	6	LASER WITH IMPROVED POWER AND FREQUENCY STA8ILITY
584	A	3,484,721	SS	BTL	11	4	67	12	X-RAY LASER
585	A	3,509,489	NS	IBM	13	4	67	5	LSR DEFLECTOR USING PIEZO XTAL AND 8RAGG ANGLE DIFFRACTN
586	A	3,676,796	NS	IUP	13	4	67	5	GENERATION OF A SINGLE FREQUENCY LIGHT RAY
587	A	3,522,552	IN	ISE	18	4	67	6	SEMICONDUCTOR LASER UNIT
588	A	3,509,490	GA	I8M	26	4	67	7	INDUCTIVE EXCITATION SYSTEM FOR PLASMA
589	A	3,471,803	NS	HAC	27	4	67	4	LASER HAVING STABILIZED OUTPUT SPECTRUM
590	A	3,519,953	NS	I8M	28	4	67	3	DIGITAL SCANLASER COUPLED TO AN INPUT LASER
591	A	3,479,613	IN	NVY	28	4	67	5	LASER DIODE
592	A	3,471,804	NS	HAC	9	5	67	9	FREQUENCY STA8ILIZED LASER
593	A	3,524,146	IN	IUP	11	5	67	6	LSR HAVING 8REWSTER ANGLE FACE AND REMOTE REFLECTOR
594	A	3,546,621	SS	AFC	15	5	67	1	BRIGHTNESS GAIN AND MODE CONTROL BY OPTICAL COMPENSATION
595	A	3,510,798	NS	TRW	16	5	67	5	HOLOCAMERA ILLUMINATOR
596	A	3,564,453	GA	CAR	19	5	67	9	CHEMICALLY PUMPED GAS LASER
597	A	3,427,567	GA	HAC	19	5	67	8	GASEOUS LASER DISCHARGE TU8E
598	A	3,500,242	GA	SAI	22	5	67	3	STATIC CO2 LASER
599	A	3,486,131	NS	8TL	26	5	67	2	DUAL CAVITY SINGLE MODE LASER
600	A	3,543,182	GA	PHL	1	6	67	6	TUBE WITH CONCENTRIC ELECTRODES

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	---DATE--- DA	MO	YR	NO. CLAIMS	PATENT DISCRIPTION
601	A	3,569,858	GA	PHL	1	6	67	1	CO2 LASER WITH METAL MIRROR ON ONE END
602	A	3,534,291	NS	GEC	7	6	67	8	IMMERSION OF FACE PUMPED LASER DEVICES
603	8	3,467,906	IN	RCA	14	6	67	7	CONSTANT GAIN LOW NOISE LIGHT AMPLIFIER
604	A	3,482,186	SS	GEC	14	6	67	8	LASER OSCILLATOR WITH SINGLE TRANSVERSE MODE OUTPUT
605	A	3,566,303	NS	UAC	15	6	67	15	ULTRASONIC CONTROL SYSTEM FOR LASERS
606	A	3,517,333	NS	BTL	16	6	67	5	DEV EMPLOYING INDUCED INHOMOGENEITIES IN NONFERRO XTALS
607	A	3,529,263	NS	TRW	16	6	67	4	EXTRACTING LIGHT FROM MODE LOCKED LASERS
608	A	3, 26,420	SS	FMC	29	6	67	7	REISSUE 3235816 SHOCK WAVE GAS IONIZATION PUMPED LASER
609	A	3,514,715	IN	RCA	29	6	67	8	MULTILAYER LIGHT EMITTING SEMICONDUCTOR DEVICE
610	A	3,560,873	IN	TEX	5	7	67	4	OPTICALLY PUMPED HG DOPED GERMANIUM IN LIQUID HE DEWAR
611	A	3,526,851	IN	RCA	10	7	67	8	FILIMENTARY STRUCTURE LSR WITH VERY NARROW ACTIVE JUNCTN
612	A	3,568, 89	GA	AIS	11	7	67	4	INTERNAL MIRROR DISTANCING, LO VOLT STAB DISCHG DEV, FM
613	A	3,487,328	NS	ASD	21	7	67	4	COOLING HEAT RADIATING ARTICLES
614	A	3,544,915	GA	ORC	24	7	67	10	GAS LASER PLASMA GUIDE
615	A	3,541,469	LQ	NVY	25	7	67	1	ADJUSTABLE RECIRCULATING LIQUID LENS LASER CELL
616	A	3,521,190	LQ	NVY	25	7	67	4	LIQUID LENS LIQUID LASER CELL
617	A	3,531,736	NS	BTL	25	7	67	2	PHASE LOCKED LASER WITH MOVING REFLECTOR
618	A	3,516, 9	GA	PKE	27	7	67	5	HIGH STABILITY LASER
619	A	3,537, 27	GA	BTL	27	7	67	3	FREQUENCY STABILIZED SINGLE MODE RING LASERS
620	A	3,575,667	NS	BTL	27	7	67	4	SINGLE MODE RING LASER
621	A	3,614,661	IN	TPV	27	7	67	15	ARRANGEMENT FOR EXCITING LIGHT WAVE CONDUCTORS
622	A	3,534,292	NS	HPC	2	8	67	8	FREQUENCY STABILIZED LASER SYSTEM
623	A	3,525,950	SS	GEC	7	8	67	6	SILVER REFLECTING SURFACE SURROUNDS ROD AND PUMP LAMP
624	A	3,521,191	NS	BDX	15	8	67	12	Q-SWITCHING APPARATUS FOR A LASER DEVICE
625	A	3,528, 30	SS	HNY	16	8	67	1	LASER ROD AND PUMPING LAMP ARE READILY REPLACEABLE
626	A	3,493,894	GA	BTL	21	8	67	5	AMP AND PHASE LOCK OF TRANSITIONS BY PARAMETRIC INTERACTN
627	A	3,550, 31	GA	BTL	21	8	67	2	AMPLITUDE AND PHASE LOCKING OF LSR TRANS BY PLASMA OSCLNS
628	A	3,564,449	NS	VAR	21	8	67	12	OPTICAL MASER
629	A	3,460, 54	SS	AFC	24	8	67	4	PUMPING SYSTEM FOR PULSED LASERS
630	A	3,492,598	GA	BTL	24	8	67	5	METHOD FOR PROCESSING GAS DISCHRAGE DEVICES
631	A	3,521,192	NS	UAC	25	8	67	8	LASER PULSE SHAPING SYSTEM
632	X	3,462,711	IN	BTL	28	8	67	8	ELECTRO-OPTIC DIODE MODULATORS
633	A	3,543,181	NS	PKE	5	9	67	5	FREQUENCY STABILIZATION SYSTEM
634	A	3,560,875	NS	NAR	11	9	67	5	BEAM ANGLE LIMITER
635	A	3,585,520	IN	HIT	13	9	67	8	PULSE TRIGGERED BY FORMATION AND TRANSIT OF HI FIELD DOM
636	A	3,701, 48	SS	AMY	15	9	67	2	MULTI ROD SINGLE PUMP SOURCE LASER
637	A	3,521,187	DY	EAK	18	9	67	12	LASER MEDIA CONTAINING COUMARIN DYE SOLUTIONS
638	X	3,467,917	GA	BTL	26	9	67	4	FIELD TUNABLE RAMAN OPTICAL DEVICE
639	A	3,643,174	NS	SAB	28	9	67	7	LASER CONSTRUCTION
640	A	3,646,472	SS	AOC	2	10	67	2	LASER STRUCTURES
641	A	3,555,452	SS	LPP	2	10	67	7	LASER PUMPED BY ANNULARLY SHAPED DIODES *****
642	A	3,508,166	NS	TRW	9	10	67	8	PASSIVE OPTICAL ISOLATOR
643	A	3,513,410	NS	UCC	10	10	67	5	LASER BEAM POWER DENSITY CONTROL FOR Q-SWITCHING
644	A	3,564,450	NS	KIC	11	10	67	5	ELECTRO-OPTIC Q-SWITCH USING BREWSTER ANGLE POCKELS CELL
645	A	3,503, 5	GA	HNY	17	10	67	4	RING LSR WITH 2 EQUAL INTENSITY FREQS GENERATED IN OP DIR
646	A	3,605, 36	GA	LSI	17	10	67	17	THERMOCHEMICALLY CONTROLLING GAS ATMOSPHERE
647	A	3,500,241	NS	BTL	23	10	67	3	PASSIVE TRANSMISSION PULSING OF A Q-SWITCHED LASER
648	A	3,537, 28	IN	RCA	23	10	67	8	CONFOCAL SEMICONDUCTOR DIODE LASER
649	A	3,622,906	IN	RCA	24	10	67	7	LIGHT EMITTING DIODE ARRAY
650	X	3,517,337	IN	IBM	26	10	67	5	MODULATION OF SCANNING BEAMS IN INJECTION LASERS

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	DATE DA	DATE MO	DATE YR	NO. CLAIMS	PATENT DISCRIPTION
651	A	3,393,372	GA	SEI	26	10	67	11	CARBON DIOXIDE LASER SYSTEMS
652	AAA	3,487,327	NS	HAC	1	11	67	8	FREQUENCY STA8ILIZED LASER
653	AAA	3,577, 96	GA	HAC	1	11	67	12	TRANSVERSE DISCHARGE GAS LASER
654	AAAA	3,774,120	NS	PRV	3	11	67	3	LSR OSCLLTR WITH INTRACAVITY AMPLITUDE STABILIZATION
655	AAAA	3,535,653	GA	IBM	15	11	67	10	MULTIPLE LOOP EXCITATION SYSTEM FOR PLASMA
656	AAAA	3,538,455	GS	LPP	24	11	67	9	LASER APPARATUS USING LIGHT EMITTING DIODES
657	AAAA	3,594,658	GS	PRV	27	11	67	9	HI PRESSURE LASER HAVING THERMAL PUMPING MEANS
658	AAAA	3,564,454	SS	TRW	28	11	67	10	LSR ROD 8IREFRINGENCE INSENSITIVE POLARIZED CAVITY
659	AAAA	3,577, 97	NS	TRW	28	11	67	3	LASER WITH CCM8INED Q-SWITCH AND CAVITY DUMP CIRCUIT
660	AAAA	3,521,193	GA	UAC	29	11	67	4	MAGNETIC FIELD 8EAM SCANNER FOR GAS LASERS
661	AAAA	3,594,661	GA	CGE	30	11	67	1	GAS LASER TUBE
662	AAAA	3,586,996	GA	CGE	1	12	67	3	MAGNETIC FIELD LASER STRUCTURE
663	A8A	3,497,828	NS	NAR	6	12	67	16	ELECTRO OPTIC Q-SWITCH
664	AXA	3,398,376	8S	PRV	11	12	67	7	RELATIVISTIC ELECTRON CYCLOTRON MASER
665	A8A	3,534,288	NS	HAC	15	12	67	7	STABILIZED LASER SYSTEM
666	AAA	3,550, 39	LQ	8TL	19	12	67	7	OPTICAL DELAY SYSTEM
667	AAA	3,582,814	NS	8TL	21	12	67	4	TWO PHOTON LIQUID LASER
668	A8A	3,480,874	LQ	CGE	26	12	67	4	LIQUID LASER CONSTRUCTION WITH 3 COAXIAL TUBES
669	8AA	3,426,286	LN	8TL	27	12	67	8	MULTIMODE OPTICAL AMPLIFIER
670	AAA	3,539,942	NS	8TL	27	12	67	1	SELF PULSING LASER
671	AAA	3,431,514	NS	SYL	29	12	67	8	LASER FREQUENCY STA8ILIZATION
672	AAA	3,562,663	GA	AMY	29	12	67	5	MODE AND Q-SWITCH MECHANISM FOR GASEOUS LASERS
673	AAA	3,559, 95	NS	LAC	5	1	68	7	NUCLEAR ENERGY PUMPED SOLID OR GAS LASER
674	AAA	3,571,745	NS	NVY	10	1	68	9	PULSE-CHARGING COUPLING LASER APPARATUS
675	AAA	3,571,746	GA	NVY	10	1	68	9	PULSED LASER APPARATUS
676	AAA	3,510,801	SS	TRW	19	1	68	15	OPTICAL PUMP SYSTEM FOR REPETITIVE OPERATION
677	AAA	3,555,45C	GA	LA8	22	1	68	5	LSR WINDOW HAVING METALLIC FRAME TO PERMIT GRIND/POLISH
678	AAA	3,575,141	GA	NIP	2	2	68	5	GAS LASER TUBE
679	AAA	3,569,856	NS	TRW	8	2	68	4	LASER FREQUENCY MODULATING SYSTEM
680	AAA	3,575,671	GA	CGE	12	2	68	8	HI POWER MONCMODE LSR WITH COUPLED CAVITIES
681	AAA	3,609,582	GD	PHL	19	2	68	5	DISCHARGE IN CAR8ONIC ACID IN A QUARTZ TUBE
682	AAA	3,571,747	GD	UAC	23	2	68	4	GAS INJECTION LASER
683	AAA	3,600,704	GA	UAC	23	2	68	10	GAS LASER USING SOLID CO2 SU8LIMING TO GAS
684	AAA	3,614,656	NS	HAZ	1	3	68	16	GAS LASER USING CO2 AND NITROGEN
685	AAA	3,526,852	GA	PRV	1	3	68	10	SPATIALLY COHERENT ARRAY OF OPTICAL ENERGY SOURCES
686	AAA	3,562,664	SS	TRW	6	3	68	14	GAS LASER WITH MEANS FOR MAINTAINING POWER OUTPUT
687	8AA	3,513,402	NS	I8M	11	3	68	9	HI-ENERGY LASER WITH MATL IN SHAPE OF TRUNCATED CONE
688	X8A	3,471,807	SS	CEA	12	3	68	23	CONTUNIOUSLY TUNA8LE PULSED LSR USING FRANCK-CONDON SHIFT
689	AAA	3,514,709	SS	NAR	13	3	68	9	AMPLIFICATION OF LASER PULSE
690	AAA	3,569,857	GA	UCC	14	3	68	3	ACHIEVING CHEMICAL EQUILI8RIUM IN SEALED OFF CO2 LASER
691	AAA	3,516, 11	SS	8TL	18	3	68	7	AIR-COOLED C-SPOILED ND YAG LASER SYSTEM
692	AAA	3,522,553	NS	8TL	18	3	68	8	PULSED LSR EMPLOYING ACTIVE A8SORPTION CELL
693	AAA	3,575,668	GA	UCC	20	3	68	4	LASER FREQUENCY STANDARD EMPLOYING AN OPTICAL LIMITER
694	AAA	3,566,304	GA	POL	20	3	68	5	GAS LSR PRESSURE CONTROL FOR MAINTAINING CONST PRESSURE
695	AAA	3,611,184	GA	PTG	21	3	68	9	LASER OPTICAL SYSTEM HAVING DIVERGENT COMPONENT
696	AAA	3,582,818	GA	8TL	27	3	68	5	DISCHG TU8E WITH CONSTRICTIVE ORIFICE IN TU8E TO CATHODE
697	AAA	3,550, 32	MB	PCA	27	3	68	8	MOLECULAR 8EAM LSR FOR USE AS FREQNENCY STANDARD
698	AAA	3,551,842	IN	TRW	28	3	68	5	LSR HAVING HIGH POWER OUTPUT AND REDUCED THRESHOLD
699	AA	3,555,451	GA	PRV	4	4	68	18	LASER COLD CATHODE APPARATUS
700	A	3,571,748	NS						AIMING APPARATUS FOR OPTICAL MASER

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	DATE DA	DATE MO	DATE YR	NO. CLAIMS	PATENT DISCRIPTION
701	A	3,544,916	SS	UAC	16	4	68	9	MULTIPLE FREQUENCY ULTRASONIC CONTROL FOR LASERS
702	A	3,581,227	NS	HNY	18	4	68	1	ADJUSTABLE THIN MEMBRANE MIRROR FOR STAB OF RING LASERS
703	A	3,588,737	GA	ENL	22	4	68	2	THERMALLY STABILIZED LASER
704	A	3,611,186	GA	PHL	25	4	68	4	TUBE INTERCONNECTING ENDS OF DISCHARGE TUBE
705	A	3,530,402	NS	PFC	26	4	68	9	FREQUENCY STABILIZATION SYSTEM
706	A	3,582,820	SS	AOC	29	4	68	9	ERBIUM LASER DEVICE
707	A	3,599,114	SS	AOC	30	4	68	4	LASER GLASS WITH CLADDING OF SELECTIVELY ABSORBING MATL
708	A	3,611,180	SS	PFC	2	5	68	4	SUPERCOOLED GE AND SI XTALS PUMPED BY IMPACT IONIZATION
709	A	3,603,895	GA	PRV	6	5	68	1	GAS LASER WITH IMPROVED CAPILLARY TUBE
710	A	3,638,139	GA	BTL	6	5	68	8	FREQUENCY SELECTIVE LASER DEVICES
711	A	3,768, 36	GA	PHL	9	5	68	3	LASER WITH GAS MIXTURE CONSISTING OF PART CARBOLIC ACID
712	A	3,555,453	NS	LRC	9	5	68	5	STABILIZATION OF LASERS
713	B	3,521,178	SS	PRV	10	5	68	20	CONTINOUSLY EMITTING SOLID STATE DEVICE
714	B	3,460, 46	NS	BTL	13	5	68	8	LASERS AND OPTICAL RESONATORS WITH BEAM TWISTING
715	A	3,541,471	NS	BTL	13	5	68	16	TRANSVERSE MODE LOCKING AND BEAM SCANNING
716	A	3,543,180	NS	BTL	13	5	68	10	TRANS AND LONG MODE LKNG BY TRAV WAVE INTRACAVITY PHS MOD
717	A	3,576,502	NS	BTL	13	5	68	16	TRANSVERSE MODE SWITCHING AND IMAGE AMPLIFICATION
718	B	3,566,297	CH	UAC	23	5	68	4	REACTION TRIGGERED BY SHOCK IN CONVERGING NOZZLE
719	A	3,617,928	GD	UAC	23	5	68	5	AERODYNAMIC WINDOW FOR GAS DYNAMIC LASER
720	A	3,665,336	GD	UAC	28	5	68	6	LASER DEVICE
721	J	3,517,336	IN	PRV	31	5	68	4	SINGLE ELEMENT THIN FILM OSCILLATOR (CODE IN NOT EXACT)
722	A	3,533, 15	SS	TRW	31	5	68	5	RADIATION BEAM DIRECTING SYSTEMS
723	A	3,560,876	CH	AVC	31	5	68	6	SUPERSONIC FLOW GASEOUS CHEMICAL CW LASER
724	A	3,533, 14	GA	MIT	4	6	68	18	RING LASER USING OSC RAD SCAT SOURCES WITHIN THE CAVITY
725	X	3,477, 41	IN	RCA	5	6	68	8	AMP MOD LIGHT BY SOLID STATE OSCILLATOR
726	B	3,571,737	SS	BTL	7	6	68	9	LASER MATL IN TRANSMISSION LINE SERVE AS AMPLIFIER
727	A	3,516, 13	SS	IBM	10	6	68	6	SCANNING LSR WITH CONJUGATE CONCENTRIC CAVITY
728	A	3,537, 29	IN	RCA	10	6	68	8	PRODUCING LIGHT A TWO WAVELENGTHS SIMULTANEOUSLY
729	A	3,550, 33	SS	WEC	11	6	68	6	CHROMIUM-DOPED GDALG3 HI ENERGY STORAGE LASER MATERIAL
730	A	3,573,669	CH	TRW	17	6	68	4	CHEMICAL LASER APPARATUS
731	B	3,609,570	GA	CDC	17	6	68	18	LIGHT EXCITED MICROWAVE MASER
732	A	3,581,228	GA	BTL	18	6	68	8	SIMLLTANEOUS TRANS AND LONG MODE LOCK USING ABSORPTN CELL
733	A	3,585,523	SS	UAC	19	6	68	1	SPHERICAL MIRROR CAVITY FOR MODE LOCKED LASER
734	A	3,593,188	NS	HAC	19	6	68	5	INTERNALLY MODULATED LASER
735	A	3,582,815	SS	CON	24	6	68	12	CAVITY CONFIGURATION IMPROVEMENTS
736	A	3,668,548	SS	WEC	26	6	68	4	SYSTEM FOR CONTINOUSLY VARIABLE PUMP PULSES
737	A	3,577, 98	NS	HAC	1	7	68	5	THERMALLY COMPENSATED LASER
738	A	3,599,115	NS	PRV	8	7	68	1	TIME SEQUENCING SINGLE LSR WITH ROT FIBER OPTIC LT GUIDE
739	A	3,600,702	NS	UCC	10	7	68	7	DIFFUSE OPTICAL PUMPING USING FLEXIBLE CERAMIC CLOTH
740	A	3,636,472	GA	AVC	10	7	68	8	PULSED DEVICE IMPLOYING ELECTRODES WITH PROJECTIONS
741	A	3,555,454	NS	IBM	15	7	68	13	ELECTRON BEAM ADDRESSED DIGITAL SCAN LASER
742	A	3,602,838	IN	IBM	18	7	68	25	ELECTRON OR PHOTON BEAM EXCITED SEMICONDUCTOR LASER
743	A	3,631,361	LQ	SIN	22	7	68	5	ROOM TEMP LIQUID LASER
744	A	3,624,542	GA	TRW	26	7	68	2	CONTROL FOR POWER OUTPUT OF GAS LASER
745	A	3,573,655	CH	PRV	30	7	68	10	MOLECULAR GAS COMBUSTION LASER
746	A	3,548,335	GA	AMY	8	8	68	13	BRUSH CATHODE DISCHARGE MASER
747	A	3,518,569	SS	AMY	9	8	68	7	CIRCULATING LIQUID CALDDING SYSTEM FOR LASER RODS
748	A	3,553,604	NS	SAB	14	8	68	10	THERMALLY STABLE APPARATUS FOR LASER DEVICE
749	A	3,628,178	NS	UAC	14	8	68	1	DIFFRACTIVE COUPLING LASER MIRROR
750	A	3,619,810	IC	CRL	19	8	68	1	ION LASER CORE

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	DATE DA	DATE MO	DATE YR	NO. CLAIMS	PATENT DISCRIPTION
751	A	3,539,941	LQ	ACC	22	8	68	10	LIQUID LANTHANIDE CHELATE LUMINESCENT SYSTEM
752	AA	3,597,700	GA	PRV	22	8	68	5	HI ENERGY LSR WITH CONTINOUS ABNORMAL GLOW DISCHARGE
753	AA	3,581,229	NSS	GEC	27	8	68	10	FACE PUMPED LSR WITH CPTICAL PATH FOLDING
754	AA	3,631,362	SSS	GEC	27	8	68	8	FACE PUMPED, FACE COOLED LASER DEVICE.
755	AAA	3,555,455	NNS	NAS	29	8	68	4	OPTICAL MODULATION OF A LIGHT SIGNAL USING SEMICONDUCTOR
756	AAA	3,594,660	NSS	SPI	29	8	68	1	MODE LOCKED LASERS
757	AB	3,668,537	NNS	SIE	31	8	68	6	LIQUID ELECTRODES FOR POCKELS CELLS
758	AA	3,588,738	NNS	HAC	3	9	68	1	FREQUENCY STABILIZED LASER
759	AA	3,609,589	NSS	PKE	3	9	68	9	MIRROR FOR RESISTING THERMALLY INDUCED WARP
760	AAB	3,577, 93	NNS	AMY	13	9	68	6	O8TAINING MULTIPLE COHERENT LASER APERTURES
761	AAB	3,571,738	NNS	BTL	18	9	68	3	FOLDED OPTICAL DELAY LINE
762	AA	3,577, 94	SSN	UAC	27	9	68	1	FRESNEL ZONE LASER COUPLING MIRROR
763	AA	3,593,191	NSS	SA8	30	9	68	8	ELECTRICALLY FOCUSSED LASED DIODE
764	AA	3,609,583	IN	TCS	30	9	68	4	CONTROLLING FREQ 8Y USING AN ABSORPTION CELL
765	AA	3,643,176	NS	GTU	30	9	68	12	SUPERCODUCTOR ELECTROMAGNETIC DEVICE
766	AA	3,617,926	IN	PKE	3	10	68	7	CU8E CORNER REFLECTOR AT ONE END OF DISCHARGE TUBE
767	A8	3,626,312	GA	AOC	4	10	68	10	LASER PREAMPLIFIER
768	AA	3,611,181	NSS	UAC	10	10	68	2	LASER DIFFRACTION GRATING COUPLING MIRROR
769	AA	3,609,585	NNS	PKE	15	10	68	13	HI POWER LASER INCLUDING MEANS FOR PROVICING POWER OUTPUT
770	AA	3,586,999	IN	RCA	16	10	68	13	FIELD EXCITED LSR USING UNIFORM DOPED SINGLE CRYSTAL
771	AAA	3,619,811	GA	RCA	17	10	68	5	GAS LASER TUBE MOUNT
772	AAA	3,624,545	SS	MOC	23	10	68	18	SEMICONDUCTOR PUMPED YAG LASER ********
773	AAA	3,571,749	GA	NVY	5	11	68	4	DUST COOLED GAS LASER
774	AAA	3,582,816	SA	HAD	5	11	68	17	LASER HEAD CONSTRUCTION
775	AAB	3,599,106	NS	AOC	6	11	68	10	HIGH INTENSITY HIGH COHERENCE LASER SYSTEM
776	AX	3,526,854	NSS	NVY	12	11	68	1	LARGE BAND-WIDTH LASER MODULATOR
777	AAB	3,626,321	SS	IBM	13	11	68	14	OPTICAL SCANNER AND METHOD FOR OPTICAL SCANNING
778	AA	3,617,917	SS	NSC	16	11	68	1	OPTICAL SCANNER AND METHOD FOR OPTICAL SCANNING USE.
779	AA	3,588,739	SA	NIP	16	11	68	4	CONVERGING ELEMENT FOR HI-POWER OUTPUT USE.
780	AA	3,611,182	GA	UAC	19	11	68	8	EXCITER DEVICE FOR SOLID STATE LASER
781	AA	3,622,910	SS	AVC	20	11	68	5	OPTICAL CHIRP PULSE GENERATOR
782	AA	3,582,822	GA	PRV	21	11	68	1	DYNAMIC CONVECTIVE COOLED LASER
783	AA	3,683,297	BA	CRL	22	11	68	6	LASER FLASH TUBE
784	AAB	3,639,854	EG	COR	22	11	68	18	OPTICAL CAVITY FOR FOLDED GAS LASER
785	AA	3,599,107	DY	SPR	25	11	68	6	ELECTRON BEAM SCAN LASER WITH PHOTOCHROMIC Q SPOILER
786	AB	3,636,474	NS	UAC	27	11	68	8	THERMALLY COMPENSATED LASER DISCHARGE STRUCTURE
787	AA	3,622,911	NS	8TL	2	12	68	2	ULTRA SHORT PULSE GENERATION USING LASER PUMPED LASERS
788	AAA	3,517,334	NS	TRW	16	12	68	9	LASER OSCILLATOR WITH MODE SELECTOR
789	AA	3,626,323	NS	PKE	19	12	68	8	GAS OR SS LASER PUMPED 8Y MULTIPLE PHOTON ABSORPTION
790	AAA	3,654,569	GS	UAC	23	12	68	10	THERMAL STA8ILIZING ARRANGEMENT FOR A LASER DEVICE
791	AAA	3,697,887	NG	PEC	23	12	68	2	AERODYNAMIC WINDOW
792	AA	3,566,305	SA	UAC	23	12	68	5	LASER FREQUENCY STA8ILIZATION SYSTEM AND METHOD
793	AAA	3,568, 90	GA	UAC	23	12	68	3	NITROGEN OZONE LASER
794	AAA	3,573,656	NS	BTL	23	12	68	7	NITROGEN HYDROGEN SELENIDE LASER
795	AAA	3,573,657	GA	UAC	23	12	68	4	NITROGEN OZONE LASER
796	AAX	3,559,102	NS	NIP	26	12	68	3	LASER OSCILLATOR WITH MODE SELECTOR
797	AA	3,575,670	IN	8TL	27	12	68	12	NITROGEN PHOSPHINE LASER
798	AA	3,617,929	GA	TEX	30	12	68	4	ULTRA-HIGH-SPEED LIGHT PULSE GENERATOR
799	AA	3,628,181	NS	RDC	1	1	69	11	ULTRA-HIGH-SPEED LIGHT PULSE GENERATOR OF LASERS
800	A	3,551,843		AMY	8	1	69	3	SYCHRONOUSLY MODE LOCKING A PLURALITY OF LASERS
									LASER HAVING MODE SUPPRESSING REGION
									GAS DISCHARGE LASERS
									NONCAVITY LASER CONFIGURATION

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	DATE DA	DATE MO	DATE YR	NO. CLAIMS	PATENT DISCRIPTION
801	A	3,638,137	NS	HAC	10	1	69	2	Q SWITCHING AND MODE LOCKING A LASER BEAM AND STRUCTURE
802	A	3,569,859	GA	NVY	13	1	69	3	CO2 LASER OPERATING AT 9.6 MICRONS USING SEL ABSORBTION
803	A	3,614,658	GA	SPI	22	1	69	12	MAINTAINING A UNIFORM GAS MIXTURE IN A DC DISCHARGE
804	A	3,581,230	GA	UAC	27	1	69	5	PASSIVE Q-SWITCH AND MODULATOR FOR CO2 LASERS
805	A	3,611,183	IG	RCA	27	1	69	1	DOUBLE ENDED ION LASER TUBE
806	A	3,624,546	NS	UAC	28	1	69	8	VARIABLE COUPLING LASER RESONATOR
807	A	3,624,547	SS	PRV	4	2	69	10	LSR PRODUCED BY CHEMICAL REACTION BET GERMINATE AND OXIDE
808	A	3,597,701	NS	ISE	13	2	69	5	MECHANICAL Q-SWITCHING OF LASERS
809	A	3,550, 34	GA	NAS	20	2	69	13	REPETITIVELY-PULSED, WAVELENGTH SELECTIVE LASER
810	A	3,711,788	NS	PEC	27	2	69	20	LASER APPARATUS (OPTICAL SHUTTER ASSEMBLY)
811	A	3,593,189	NS	GTI	27	2	69	11	FREQUENCY STABILIZATION SYSTEM
812	A	3,597,702	SS	CGE	5	3	69	4	METHOD FOR TRIGGERING A SOLID LASER
813	A	3,636,473	SS	AOC	6	3	69	11	COMPOSITE GLASS LASER ROD
814	A	3,628,179	SS	AOC	12	3	69	8	STACKED COMPOSITE PLATE LASER
815	A	3,641,456	SS	PEC	14	3	69	7	PRODUCING HIGH POWER SINGLE FREQ RADIATION
816	A	3,569,861	NS	NVY	14	3	69	4	XENON FLASH LAMP FOR LSR PUMPING IN LIQUID NITROGEN
817	A	3,614,659	SS	BTL	14	3	69	8	SYNCHRONOUS COUPLING OF LSR TO COMMON RESONATOR
818	A	3,579,145	MD	BTL	21	3	69	3	MODULATOR STABILIZATION CIRCUITS
819	A	3,617,930	SS	AOC	24	3	69	9	LASER HAVING CONTROLLABLE FREQUENCY SPECTRUM
820	A	3,621,456	IN	PRV	24	3	69	12	DISK LASER SYSTEM
821	A	3,539,945	GA	AMY	25	3	69	3	MODULATION DIODES FOR MAXIMUM OPTICAL POWER
822	A	3,614,660	AS	UAC	27	3	69	5	EMPLOYING ALIPHATIC NITRILES AS A LASING GAS
823	A	3,618,129	SS	UAC	27	3	69	1	SELECTED CYANOGEN HALIDES AS LASING GASES
824	A	3,596,202	MV	8TL	28	3	69	3	CO2 LASER OPERATING ON VIBRATIONAL-ROTATIONAL TRANSITION
825	A	3,602,836	SS	AOC	1	4	69	6	LASER STRUCTURE WITH A SEGMENTED ROD
826	A	3,621,457	SS	AOC	1	4	69	11	UNITARY GLASS LASER WITH ASYMMETRICAL PUMPING
827	A	3,624,548	SS	8TL	9	4	69	5	DISCHARGE TUBE CONFIGURATION OF METAL VAPOR ION LASER
828	A	3,646,473	SS	PRV	10	4	69	8	CLAD GLASS LASER ROD
829	A	3,611,185	SS	PRV	10	4	69	14	UNITARY LASER SYSTEM WITH OVAL SHAPED ROD OF LASER GLASS
830	A	3,588,740	IN	AMY	14	4	69	2	PULSED GAS ION LASER
831	A	3,624,549	IN	BTL	16	4	69	16	INFRARED DIODE PUMPED VISIBLE LASER
832	A	3,593,190	IN	TEX	16	4	69	12	ELECTRON BEAM PUMPED LSR WITH ARRAY OF MOSAIC ELEMENTS
833	A	3,595,109	SS	BTL	16	4	69	11	SECOND PHOTON VISIBLE EMITTING PHOSPHOR USED ON IR DIODE
834	A	3,633,126	SS	GEC	17	4	69	10	MULT INTERNAL REFLECTION FACE PUMPED LASER
835	A	3,646,474	SS	AOC	21	4	69	9	SYMETRICALLY PUMPED SLAB LASER
836	A	3,629,723	SS	AOC	21	4	69	9	ATHERMAL LSR USING A ONE-EIGHTH WAVE FARADAY ROTATOR
837	A	3,668,536	SS	CGE	24	4	69	2	LIGHT AMPLIFIER STAGES
838	A	3,569,860	SS	AOC	25	4	69	9	PLURALITY OF LSR MATL SEGMENTS FOR HIGH POWER DISSIPATION
839	A	3,585,524	SS	BTL	28	4	69	10	ION LASERS EMPLOYING GAS MIXTURES
840	A	3,628,173	SS	BTL	28	4	69	5	MODE SEL AND STAB USING BIREFRINGMENT ETALON
841	A	3,652,951	SS	AOC	28	4	69	6	PRODUCING LASER OUTPUT ENERGY PULSES OF DESIRED WIDTH
842	A	3,605, 37	SS	BTL	2	5	69	7	CURVED JUNCTION LASER DEVICE
843	A	3,617,931	SS	BTL	5	5	69	11	ACOUSTO-OPTIC DEVICES USING LEAD MOLYBDATE AND REL COMPND
844	A	3,689,850	SS	ABO	6	5	69	4	NEUTRALIZING TEMP GAIN VARIATIONS IN OPT PUMPED LASER ROD
845	A	3,582,817	SS	AEC	12	5	69	3	GAS LASER HAVING EXCITATION CHAMBERS
846	A	3,628,180	SS	PRV	12	5	69	9	TWO SLAB LASER WITH COMPENATION FOR LENS POWER
847	A	3,611,187	SS	SYL	14	5	69	2	MODE LKD LSR MODULATED BY STAB NONDAMPED RELAX PULSES
848	A	3,611,188	SS	AOC	19	5	69	6	YTTERBIUM LASER DEVICE
849	A	3,622,912	SS	PEC	22	5	69	12	INTRA-CAVITY POLARIZATION MODULATED LASER
850	A	3,599,113	SS	WOB	25	5	69	6	LASER DEVICE

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B51	A	3,5B6,997	SS	BTL	26	5	69	10	STABILIZED MODE LOCKED LASER ARRANGEMENT
B52	X	3,699,47B	GA	BTL	26	5	69	B	BLACK+WHITE DISPLAY USING SCANNING ARGON LASER
B53	A	3,518,570	SS	AMY	2	6	69	1	LASER EXCITER SYSTEM
B54	A	3,569,B62	GA	PRV	2	6	69	2	GAS LASER EXCITER
B55	C	3,740,661	IN	BTL	6	6	69	14	MINOR LOBE SUPPRESSION IN SEMICONDUCTOR INJECTION LASERS
B56	X	3,663,B97	IN	IUP	6	6	69	11	MODULATING A LASER BEAM.
B57	A	3,670,263	NS	AOC	16	6	69	1	LASER STRUCTURE
B5B	A	3,617,932	IN	BTL	16	6	69	8	METHOD FOR PULSE WIDTH MODULATING SEMICONDUCTOR LASERS
B59	A	3,617,939	NS	BTL	16	6	69	7	PUMPING LASERS WHICH RAD AT WAVELENGTHS SHORTER THAN VIS
B60	A	3,5B1,231	NS	AFC	17	6	69	2	ULTRA-STABLE LSR CAVITY MIRROR SUPPORT ASSEMBLY
B61	A	3,609,5B6	SS	BTL	18	6	69	4	PULSED TRANSMISSION MODE Q-SWITCHING
B62	A	3,617,933	GA	KKH	21	6	69	3	GENERATING OSCILLATION IN KRYPTON LASER
B63	A	3,624,551	GA	NAR	27	6	69	8	SELECTIVELY TUNABLE GASEOUS LASER
B64	A	3,648,193	NS	SYL	2	7	69	5	MODE LOCKED FREQUENCY DOUBLED LASER SYSTEM
9o5	A	3,636,471	IN	MIT	3	7	69	21	ENHANCING RADIATION FROM INDIRECT GAP SEMICONDUCTORS
B66	A	3,613, 27	GA	SAB	7	7	69	6	GAS LASER WITH COLD CATHODE DISCHARGE
B67	A	3,634,779	SS	ILS	7	7	69	2	HIGH INVERSION LASER DEVICE
B6B	A	3,626,322	GA	AUC	9	7	69	2	ELIMINATING DOMINANCE OR OSCILLATIONS AT ONE WAVELENGTH
B69	C	3,747, 21	SF	NVY	18	7	69	4	WIDE RANGE CONTINUOUSLY TUNABLE THIN FILM LASER
B70	A	3,573,653	SF	NVY	18	7	69	7	CONTINOUSLY TUNABLE LSR EMPLOYING ELECTRIC FIELD EFFECT
871	A	3,573,654	SF	NVY	18	7	69	10	NARROW BAND TUNABLE LASER OSCILLATOR AMPLIFIER
872	A	3,579,142	SF	NVY	18	7	69	11	THIN FILM LASER
B73	A	3,617,937	SS	WEC	1B	7	69	8	ND DOPED CALCIUM FLUOROAPATITE LASER CRYSTAL
874	B	3,579,130	SS	PRV	1B	7	69	6	THIN FILM ACTIVE INTERFERENCE FILTER
B75	A	3,644,B42	NS	NIP	22	7	69	2	HARMONIC GENERATOR WITH TEMP EFFECTING PHASE MATCHING
B76	A	3,651,424	NS	NIP	24	7	69	4	MODE LOCKED PHASE STABILIZED LASER DEVICE
877	A	3,586,99B	GA	PRV	28	7	69	12	PULSED LASER OUTPUT CONTROL
B78	A	3,638,140	NS	HAC	2B	7	69	9	LASER COOLING SYSTEM
B79	A	3,624,552	SS	AMY	5	B	69	2	GLASS LASER COUPLING REFLECTOR
BB0	X	3,691,484	NS	NRD	13	8	69	1	ELECTRO-OPTICAL MODULATORS
881	A	3,619,812	MV	GDC	25	8	69	7	METALLIC VAPOR LASER
B82	B	3,657,733	SS	BDX	25	8	69	2	RING LASER
BB3	A	3,696,307	GA	HMC	29	B	69	1	CAPACITOR LASER (TEA LASER)
884	A	3,617,934	NS	PRV	2	9	69	B	CONVERSION OF TANG AND RADIAL POLARIZATION CO-ORD TO RECT
BB5	B	3,624,531	NS	WEC	5	9	69	6	LASER RESONATOR ASSEMBLAGE
BB6	A	3,621,461	GA	AMY	9	9	69	24	SELF-PUMPED ELECTROADIABATIC LASER
BB7	B	3,617,91B	NS	NVY	9	9	69	5	RAPID TEMP SCANNING OF TEMP TUNED OPT PARAMETRIC OSCLLTRS
BB8	A	3,641,453	GA	UAC	10	9	69	5	MODIFIED OPEN CYCLE GAS LASER SYSTEM
B89	A	3,668,549	GD	UAC	10	9	69	21	EXTENDED CLOSED CYCLE GAS LASER SYSTEM
B90	A	3,668,550	GA	UAC	10	9	69	4	GAS LASER LOW IONIZATION ELECTRIC DISCHAPGE
891	A	3,641,457	GA	UAC	10	9	69	45	HIGH PERFORMANCE GAS LASER SYSTEM
B92	A	3,634,77B	GA	UAC	10	9	69	10	CLOSED CYCLE GAS LASER SYSTEM
893	A	3,743,963	GA	UAC	10	9	69	11	TRANSVERSE GAS LASER
B94	A	3,648,194	GA	UAC	10	9	69	13	SEMICLOSED GAS LASER SYSTEM
B95	A	3,725,811	SS	WEC	15	9	69	16	LASER AND FLCURESCENT CRYSTALLINE MATERIALS
896	A	3,646,475	GA	SRL	16	9	69	9	VORTEX TUBE LASER
B97	A	3,659,221	SS	WEC	22	9	69	2	LASER MATERIAL
898	A	3,593,194	SS	NAS	2	10	69	5	LASER COOLER AND ULTRAVIOLET FILTER
899	A	3,624,553	IN	BTL	6	10	69	5	CYLOTRON LASER IN A P-TYPE SEMICONDUCTOR
900	A	3,611,1B9	SS	SAI	7	10	69	9	DIFFUSE SOLID STATE LASER CAVITY

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	---DATE--- DA	MO	YR	NO. CLAIMS	PATENT DISCRIPTION
901	A	3,641,458	NS	CDC	13	10	69	12	MODE SELECTIVE LASER WITH SMALL FDBK REF AND DIF CPLD OUT
902	A	3,676,79B	NS	SPR	13	10	69	2	COOLING SYSTEM FOR LASER MEDIA
903	A	3,621,458	NS	HAC	13	10	69	B	FLASHTUBES WITH LOW TRIGGERING LEVELS
904	A	3,611,190	SS	AOC	16	10	69	6	LSR STRUCTURE WITH SEGMENTED LASER ROD
905	A	3,584,312	SS	RAY	20	10	69	6	SPIKELESS SINGLE MODE LASER
906	A	3,613, 28	NS	BTL	21	10	69	5	MODE-LOCKED LASER
907	A	3,609,587	GA	HAC	27	10	69	1	GAS LASER WITH ADJUSTABLE MIRROR
908	A	3,626,324	NS	I8M	27	10	69	5	VOLUME REFLECTOR FOR LASER CAVITIES
909	A	3,665,338	NS	SYN	28	10	69	6	VARIABLE FREQUENCY IR SOURCE
910	A	3,649,931	NS	SPR	3	11	69	10	FREQ BIASING SYSTEM FOR RING LASER
911	A	3,611,191	NS	PRV	3	11	69	11	GAS DISCHARGE PUMPING DEVICE
912	A	3,626,325	GA	BRI	10	11	69	15	PULSED GAS LASER WITH RADIATION COOLING
913	X	3,743,969	NS	NAR	12	11	69	5	MODULATION SERVO CONTROL FOR FM RING LASER GYRO
914	B	3,646,462	SS	AOC	14	11	69	10	FIBER FOR DISTRTION-FREE PROPAGATION
915	X	3,617,942	NS	BTL	14	11	69	7	IRON BORATE DEVICES WITH MAGNETO OPTIC EFFECTS
916	A	3,729,690	SS	AOC	17	11	69	29	MEANS FOR PRODUCING AND AMPLIFYING OPTICAL ENERGY
917	A	3,643,177	SS	WEC	17	11	69	B	OPTICAL MASER
918	A	3,611,231	NS	AMY	17	11	69	B	Q-SWITCHED FREQUENCY DOUBLING LASER
919	A	3,633,127	GA	AVC	17	11	69	10	PULSED LASER DEVICE WITH IMPROVED DISCHRAGE CIRCUIT
920	A	3,605, 39	GA	I8M	20	11	69	B	MULTICOLOR LASER FREQUENCY SELECTOR
921	A	3,643,178	NS	TRW	24	11	69	6	ELECTROMAGNETIC RADIATION BEAM DIRECTING SYSTEMS
922	A	3,646,476	GA	CRL	24	11	69	5	PULSED GAS ION LASER
923	A	3,684,979	DY	AVC	24	11	69	12	TRANSVERSE DYE LASER WITH A PULSED NITROGEN LASER
924	Q	3,766,487	NS	CIL	27	11	69	2	DISCHARGE TUBE WITH DISMOUNTABLE ELECTRODE
925	A	3,641,459	IN	BTL	1	12	69	13	NARROWING PW AND STAB PRR IN LASER WITH SELF INDUCED PULS
926	A	3,711,786	GA	SAT	5	12	69	3	DETERMINATION OF FREQUENCY OF LASER RADIATION
927	A	3,626,326	SS	TRW	B	12	69	16	TIME VARIABLE REFLECTIVITY LASER ACTUATING CIRCUIT
92B	A	3,686,584	GA	SAB	11	12	69	5	GAS LASER WITH CAPILLARY TUBE THAT ACTS AS MODE SELECTOR
929	A	3,609,590	NS	NVY	11	12	69	4	EXPANDED LASER BEAM OUTPUT
930	A	3,621,459	NS	PRV	11	12	69	5	BROADBAND LASER AMPLIFIER
931	X	3,668,558	NS	MVX	11	12	69	7	SURFACE WAVE INTERFERENCE MODULATOR
932	A	3,710,279	NS	BTL	15	12	69	6	APPARATUSES FOR TRAPPING AND ACCEL NEUTRAL PARTICLES
933	A	3,713, 43	GA	YRD	19	12	69	9	GAS LASERS WITH ELECTRICALLY CONDUCTIVE PLASMA TUBE
934	A	3,614,662	SS	PAY	19	12	69	11	LASER WITH MONOCRYSTALLINE YALO3 DOPED WITH ND+3 IONS
935	A	3,639,855	SS	BTL	19	12	69	1	LASER DEVICE USING MAGNETICALLY SATURABLE ROD
936	A	3,585,521	SF	WEC	22	12	69	2	HI VOLT ELECTRON PUMPED TRANSITIONS INVOLVING PHONONS
937	A	3,609,588	NS	AMY	30	12	69	2	REPETITIVELY PULSED HIGH PEAK POWER LASER
938	A	3,611,193	SS	AOC	30	12	69	10	HEADER FOR LASER ROD
939	A	3,660,779	SS	AOC	2	1	70	B	ATHERMALIZATION OF LASER RODS
940	X	3,611,207	IN	PRV	5	1	70	10	WIDE APERTURE ELECTROOPTIC MODULATOR
941	X	3,652,956	NS	BTL	23	1	70	21	COLOR VISUAL DISPLAY USING VISIBLE BLUE LASER
942	A	3,665,335	SS	GEC	26	1	70	6	COOLABLE SLAB LASER
943	A	3,681,709	AR	UAC	27	1	70	5	DIFFRACTION COUPLED LASER OSCILLATOR FOCUSING SYSTEM
944	A	3,622,907	GA	UAC	27	1	70	4	COMPOSITE OSCILLATOR AMPLIFIER LASER
945	A	3,670,258	SS	AOC	2	2	70	1	FREQ DOUBLED ND GLASS WITH LITHIUM NIOBATE CRYSTAL
946	A	3,701, 42	NS	HPC	3	2	70	10	OC MOTOR CIR FOR ROT POLARIZER FOR STABILIZATION SYSTEM
947	A	3,602,835	SS	PRV	9	2	70	1	LONG LASTING CW LSR OF LOW PUMP POWER
948	X	3,691,483	IN	PRV	9	2	70	5	PHASED ARRAY LASER SOURCE
949	A	3,662,281	SS	UCC	11	2	70	7	COMPENSATING BIREFRINGENCE IN LASER SYSTEMS
950	A	3,609,584	SS	UCC	11	2	70	7	COMPENSATING THERMAL LENSING IN A LASER SYSTEM

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLOS PAT	---DATE--- DA	MO	YR	NO. CLAIMS	PATENT DISCRIPTION
951	A	3,701, 43	IN	MDC	16	2	70	3	NEGATIVE RESISTANCE LIGHT EMITTING DIODE DEVICE
952	A	3,710,277	DY	XEN	17	2	70	5	LIGHT PUMPED LASER
953	A	3,697,889	NS	XEN	17	2	70	7	TUNABLE LASER
954	A	3,626,317	NS	IBM	19	2	70	27	DIGITALIZED SCANLASER USING FLY'S EYE LENS ARRAY
955	D	3,771, 66	GA	HPC	24	2	70	17	GAS LASER
956	A	3,748,595	MV	PKE	6	3	70	5	HE CD LASER AND METHOD FOR OPTIMUM OPERATION
957	A	3,670,256	GA	CLO	9	3	70	8	LASER GUIDE CONSTRUCTION
958	A	3,670,257	GA	CLO	9	3	70	4	METHOD OF GAS ION LASER ACTION
959	A	3,626,318	SS	AOC	10	3	70	6	TANDEM OSCILLATOR DISK AMPLIFIER
960	A	3,699,472	SS	AOC	10	3	70	10	ATHERMALLY STABLE LASER DEVICE
961	A	3,679,995	LQ	IBM	11	3	70	24	OPTICALLY PUMPED LIQUID LASERS
962	P	3,715,682	SS	AOC	19	3	70	9	RECTANGULAR DISC LASER
963	A	3,628,172	SS	NAR	19	3	70	6	HI-POWER DISSIPATION LASER SEGMENT MOUNTING HOLDERS
964	A	3,646,468	NS	UAC	20	3	70	5	SERVO AIDED INJECTION PHASE LOCKED LASER OSCILLATOR
965	A	3,646,469	NS	UAC	20	3	70	4	TRAVELLING WAVE REGENERATIVE LASER AMPLIFIER
966	A	3,613, 26	GA	UAC	20	3	70	4	PLASMA TUBE IMPEDANCE VARIATION FREQUENCY STABILIZED LSR
967	A	3,622,908	GA	UAC	20	3	70	3	DITHERED GAIN CHARACTERISTIC STABILIZATION OF A GAS LASER
968	X	3,747, 22	NS	NIP	20	3	70	4	STRONTIUM NICBATE ELECTRO-OPTIC MODULATOR
969	A	3,657,735	SS	RCA	20	3	70	7	ELECTRON BEAM EXCITED LASER
970	A	3,720,884	NS	MIT	23	3	70	11	COMPRESSION OF OPTICAL LASER PULSES
971	A	3,740,662	GA	CGE	23	3	70	18	LASER DISCHARGE TUBE
972	A	3,602,837	IO	AMY	31	3	70	12	EXCITING AN ION LASER AT MICROWAVE FREQUENCIES
973	X	3,716,804	SS	PRV	31	3	70	20	INTEGRATED OPTICAL-ELECTRONIC SOLID STATE SYSTEM
974	A	3,628,174	GA	BTL	1	4	70	12	OPT PUMPED MILLIMETER AND SUBMILLIMETER WAVE LASERS
975	A	3,670,259	SS	AOC	13	4	70	9	DOUBLE Q SWITCH LASER
976	A	3,626,319	SS	WLP	14	4	70	8	UNITARY LASER STRUCTURE
977	A	3,614,652	GA	PRV	24	4	70	1	OPTICAL WINDOWS USING GALLIUM ANTIMONIDE
978	X	3,731,231	NS	CSF	24	4	70	9	ACOUSTO-OPTICAL MODULATOR SYSTEMS USEING BLK BIFRNENT MAT
979	A	3,663,890	NS	UCC	27	4	70	8	TWO CAVITY LASER
980	A	3,605, 38	GA	IBM	30	4	70	12	POP INVER AND GAIN IN MOLECULAR GAS EXCIT BY VIB EXCIT H
981	A	3,758,875	IN	BTL	1	5	70	9	DOUBLE HETEROSTRUCTURE JUNCTION LASERS
982	A	3,644,841	IO	BTL	4	5	70	6	FREQ STABILIZED SINGLE MODE RING LASER
983	A	3,617,938	NS	UAC	4	5	70	5	POLARIZING LASER MIRROR
984	X	3,644,846	GA	BTL	4	5	70	6	MODULATION BY SUB-MM-WAVE SIGNALS USING HCN CW LASER
985	A	3,656, 67	LQ	COC	8	5	70	3	LASER CELL
986	A	3,683,295	GA	RCA	8	5	70	14	GAS LASER DISCHARGE TUBE FOR METAL VAPOR
987	A	3,670,260	NS	AOC	15	5	70	24	CONTROLLED OPTICAL BEAM FORMING DEVICE
988	A	3,599,117	GA	AMY	18	5	70	19	METHOD FOR TRACKING INVISIBLE GAS LASER BEAM
989	A	3,586,995	NS	HAC	21	5	70	9	MULTIBEAM LASER
990	X	3,659,225	NS	NAS	21	5	70	15	PUMPING SYSTEM INCLUDING XENON FILLED FLASH LAMP
991	A	3,641,454	GA	AEC	25	5	70	7	ELECTRON BEAM PUMPED GAS LASER SYSTEM
992	N	3,657,826	IN	NVY	25	5	70	7	SEMICONDUCTOR LASER MARKSMANSHIP TRAINING DEVICE
993	A	3,660,780	IN	TSE	26	5	70	10	SEMICONDUCTOR LASERS
994	A	3,673,513	CH	AEC	26	5	70	12	ELECTRON BEAM INITIATED CHEMICAL LASER SYSTEMS
995	A	3,757,250	EB	MMM	1	6	70	12	ELECTRON BEAM LASER
996	A	3,596,201	NS	HAC	8	6	70	3	FREQUENCY STABILIZED LASER
997	A	3,633,124	SS	BTL	10	6	70	6	LASER WITH FEEDBACK CIRCUIT FOR CONT RELAXATION OSCILLTN
998	A	3,663,891	LQ	GTE	12	6	70	11	CELL FOR USE IN A CIRCULATING LIQUID LASER
999	A	3,679,999	NS	GEC	12	6	70	4	LASER COOLING APPARATUS
1000	A	3,663,892	GA	BTL	15	6	70	10	METAL ION LASER HAVING AN AUXILIARY GAS

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	DATE DA	DATE MO	DATE YR	NO. CLAIMS	PATENT DISCRIPTION
1001	A	3,660,778	GA	PRV	16	6	70	12	LASER BEAM FOLDING DEVICE
1002	A	3,660,776	AR	MAT	22	6	70	4	MIRROR MEANS FOR LASER STRUCTURES
1003	A	3,633,125	GA	RAY	22	6	70	24	MEANS FOR SPECIFICALLY CREATING AND MAINT TURBULANCE
1004	A	3,675,152	SS	ADC	24	6	70	12	COMPENSATOR FOR RAD REF INDEX GRADIENT IN DISK LASER
1005	A	3,638,138	SS	NVY	25	6	70	3	CADMIUM PHOSPHIDE LASER
1006	A	3,721,915	GD	AVC	29	6	70	50	ELECTRICALLY EXCITED FLOWING GAS LASER AND OPERATION METH
1007	A	3,701, 44	IN	BTL	29	6	70	2	OPTICAL COUPLING OF ADJACENT STRIPE CONTACT SEMI LASERS
1008	A	3,675,150	IN	I8M	30	6	70	17	INTERNAL MODULATION USING ACOUSTIC WAVES
1009	A	3,745,483	GA	PKE	6	7	70	9	INERT GAS LASER WITH CONTIUOUS GAS FLOW
1010	A	3,621,460	GA	AMY	6	7	70	9	SPUTTERED VAPOR LASER
1011	D	3,704,377	IN	III	10	7	70	7	LASER COMPRISING FRESNEL OPTICS
1012	A	3,652,954	SS	PRV	10	7	70	4	LASER DEVICE
1013	A	3,631,360	SS	PRV	10	7	70	6	ELECTRO-OPTICAL STRUCTURES USING FRESNEL OPTICAL SYSTEMS
1014	A	3,641,455	GA	NAR	13	7	70	5	CHEMICAL EQUILI8RIUM IN SEALED CO2 LASER
1015	A	3,663,893	SS	BTL	13	7	70	2	HIGH EFFICIENCY DIODE PUMPED LASERS******
1016	A	3,676,795	IN	MIT	13	7	70	28	MULTIPLE FREQUENCY LASER APPARATUS AND METHOD
1017	A	3,619,809	SS	HAC	13	7	70	5	SEALING ARRANGEMENT FOR LASER COOLING SYSTEM
1018	A	3,747, 19	NS	UCC	16	7	70	6	METH TO STABILIZE AMP AND REP FREQ OF REP Q SWITCHED LASR
1019	A	3,646,470	NS	PRV	16	7	70	6	STIMULATED RADIATION CAVITY STRUCTURE
1020	G	3,706,942	CH	UAC	17	7	70	1	PULSED HYDROGEN FLOURIDE LASER
1021	A	3,665,337	SS	UCC	17	7	70	4	MEANS FOR SEALING LASER RODS
1022	A	3,718,868	GA	CWR	20	7	70	7	INVERTED LAM8 DIP STA8ILIZED HE NE LASER
1023	A	3,662,282	NS	CSF	24	7	70	2	STIMULATED EMISSION SOURCE OF LIGHT
1024	A	3,621,455	IN	PRV	28	7	70	7	PINCH EFFECT LASER
1025	A	3,777,281	GA	PRV	3	8	70	8	SEAL AND METHOD OF MAKING SAME
1026	A	3,679,996	SS	GEC	3	8	70	30	FACE PUMPED LASER DEVICE
1027	A	3,634,777	SS	NIP	3	8	70	13	OPTICAL PUMPING DEVICE FOR SOLID STATE LASER
1028	A	3,728,639	NS	8SC	4	8	70	10	ELECTROMAGNETIC INTENSIFIER
1029	X	3,714,607	NS	HPC	7	8	70	7	ACOUSTO-OPTIC MODE DECOUPLING OF RING LASER
1030	A	3,622,909	GA	UCC	10	8	70	4	HIGH REPETITION RATE Q-SWITCHED GAS LASER
1031	A	3,624,543	GA	LSI	10	8	70	10	SEGMENTED CERAMIC DISCHARGE TU8E WITH INTEGRAL RETN PATH
1032	A	3,667, 68	SS	AMY	17	8	70	13	NUCLEAR CHARGED SELF SUSTAINING LASER
1033	A	3,683,300	GA	PRV	19	8	70	9	LASER CAPILLARY SUPPORT SPACER
1034	A	3,662,284	GA	HMC	20	8	70	4	DOUBLE DISCHARGE LASER
1035	A	3,696,308	SS	HAD	21	8	70	16	SEGMENTED LASER APPARATUS AND METHOD OF MAKING SAME
1036	A	3,675,153	SS	GEC	1	9	70	4	LASER OSCILLATOR CONSTRUCTION
1037	A	3,706, 51	LQ	CGE	4	9	70	6	LIQUID LASER
1038	A	3,708,759	LQ	CGE	4	9	70	5	LIQUID LASER
1039	A	3,691,477	AP	HAC	4	9	70	10	DIFFRACTION GRATING COUPLED LASER RING RESONATORS
1040	A	3,781,708	GA	PRV	5	9	70	4	DC DISCHARGE GAS LASER WITH NOVEL DISCHARGE TUBE
1041	A	3,643,175	GA	NTP	10	9	70	8	USE OF MERCURY IN CO2 LASER
1042	A	3,761,838	GA	NTP	11	9	70	6	ROOM TEMP CO LASER
1043	P	3,702,973	GA	AVC	17	9	70	29	LASER OR OZONE GENERATOR WITH UNIFORM DISCHARGE
1044	A	3,688,215	CH	AFC	21	9	70	1	CONTINOUS WAVE CHEMICAL LASER
1045	A	3,711,785	SS	DII	24	9	70	2	HIGH POWER SEGMENTED LASER DEVICE
1046	A	3,671,882	GD	NVY	25	9	70	2	MIXING GAS IN A FLUID MIXING LASER
1047	A	3,675,151	OY	UAC	25	9	70	7	SUPERADIANT TRAVELING WAVE OYE LASER
1048	B	3,720,877	MV	I8M	25	9	70	3	DISCHARGE TU8E USING METAL AND SEMI METAL COMPOUNDS
1049	A	3,750, 49	GA	PRV	30	9	70	2	LASER TRIMMING TOOL
1050	A	3,696,310	IN	8TL	1	10	70	22	MODE LOCKING IN SEMICONDUCTOR LASERS

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	---DATE--- DA	MO	YR	NO. CLAIMS	PATENT DISCRIPTION
1051	A	3,713, 32	SS	WEC	1	10	70	7	Q SWITCHING LASER WITH ELECTRONIC CONT OUTPUT COUPLING
1052	A	3,675,154	SS	BTL	1	10	70	12	DISPERSION COMPENSATOR IN LASERS
1053	A	3,670,262	GA	HAC	2	10	70	3	OISCHRAGE AND RET PATHS THRU COMMON CYLINDRICAL BODY
1054	A	3,626,320	NS	IBM	5	10	70	3	IMAGE OISPLAY APPARATUS
1055	A	3,790,899	GA	CGE	9	10	70	1	DISCHARGE TUBE
1056	A	3,694,768	NS	SAI	12	10	70	9	MEANS FOR ENHANCING THE TEM OUTPUT MODE OF A LASER
1057	B	3,713, 30	GA	AVC	12	10	70	23	PRODUCING POPULATION INVERSION BY EXPANSION
1058	A	3,683,296	SS	TEX	13	10	70	7	HIGH EFFICIENCY LASER CAVITY
1059	A	3,684,980	SS	TEX	13	10	70	8	HI EFFECTIVE ABSORPTION COEFFICIENT LASER RODS
1060	A	3,688,216	LQ	GTE	16	10	70	9	CELL FOR USE IN CIRCULATING LIQUID LASER
1061	A	3,735,278	DY	CZS	20	10	70	5	WAVELENGTH SELECTION IN LASERS WITH BROAD BAND EMISSION
1062	A	3,671,883	GA	AGA	20	10	70	6	HIGH GAS FLOW IN OISCHARGE TUBE OF GAS LASER
1063	A	3,689,851	GA	MMC	20	10	70	6	PHASE LOCKED FAR-INFRARED LASER
1064	A	3,662,279	GA	PRV	20	10	70	14	CONTROLLING THE FREQUENCY OF A LASER BEAM
1065	A	3,701, 45	GD	UAC	23	10	70	20	CHEMICAL MIXING LASER
1066	A	3,702,974	SS	UCC	26	10	70	5	REO OF BIREFRINGENCE IN CRYSTAL BY CONTROL GROWTH DIR
1067	A	3,696,309	SS	TEX	30	10	70	6	FLASH LAMP Q SWITCHED LASER SYSTEM
1068	A	3,659,220	SS	HOL	2	11	70	16	LASER CONSTRUCTION
1069	A	3,675,155	SS	AOC	3	11	70	7	SENSITIZING LUMINESCENCE OF ERBIUM WITH MOLYBDENUM
1070	A	3,670,261	GA	HAC	9	11	70	5	ANODE OESIGN FOR GAS OISCHRAGE LASERS
1071	A	3,691,478	NS	AMY	9	11	70	6	LASER ENERGY MONITOR AND CONTROL
1072	A	3,662,280	CH	AEC	16	11	70	9	EXPLOSIVELY DRIVEN PULSED CHEMICAL LASER
1073	H	3,748,593	IN	MIT	17	11	70	11	METHOD FOR CONSTRUCTION OF SEMICONDUCTOR MAIL FOR A LASER
1074	P	3,711,789	IN	TEX	18	11	70	18	OIODE ARRAY ASSEMBLY FOR OIODE PUMPED LASERS
1075	X	3,691,482	NS	BTL	19	11	70	9	SINGLE COLOR DISPLAY USING SCANNING LASER BEAM
1076	A	3,678,410	LQ	GTE	24	11	70	7	TRANSVERSE FLOW LASER CELL
1077	A	3,708,758	GA	BLI	27	11	70	9	LASER PUMPING APPARATUS
1078	G	3,723,902	GA	BTL	30	11	70	8	CO2 LASER USING MULT GASES INCLUDING OXYGEN AND WATER VA
1079	G	3,745,482	GA	BTL	30	11	70	7	CO2 LASER EMPLOYING MULTIPLE GASES INCLUDING HELIUM
1080	A	3,656, 68	NS	BTL	3	12	70	12	RESONANT SELF PULSING ACOUSTO OPTICAL MODULATOR
1081	A	3,735,285	SS	PHL	4	12	70	3	SOLID STATE LASER
1082	A	3,649,930	GA	PRV	4	12	70	7	FREQ STAB OF SINGLE MODE GAS LASER
1083	H	3,702,975	IN	BTL	9	12	70	1	LOW THRESHOLD STRIPE GEOMETRY INJECTION LASER
1084	A	3,735,279	NS	HAC	10	12	70	6	COLINEAR HETERODYNE FREQUENCY MODULATOR
1085	B	3,663,886	NS	NAS	17	12	70	6	PARAMETRIC AMP WITH IDLER CIRCUIT FEEDBACK
1086	A	3,783,404	GA	NIP	18	12	70	5	GAS LASER
1087	K	3,739,296	NS	CBS	18	12	70	22	LASER SYSTEMS AND CONTROL SYSTEMS
1088	A	3,678,411	NS	TRW	18	12	70	11	LASER Q SWITCHING MONITERING METHOD AND APPARATUS
1089	A	3,694,770	GD	UAC	18	12	70	10	LIQUID FUEL GAS DYNAMIC MIXING LASER
1090	A	3,740,663	SS	RAY	21	12	70	7	Q SWITCHED LASER SYSTEM
1091	A	3,676,797	GA	UAC	21	12	70	4	ATOMIC FLOURINE LASER
1092	A	3,685,217	GA	TRW	21	12	70	10	LASER COLD CATHODE ARRANGEMENT
1093	A	3,688,217	GA	TRW	21	12	70	10	COLD CATHODE ARRANGEMENT
1094	A	3,676,799	NS	BTL	28	12	70	4	FREQUENCY STABILIZED LASER
1095	A	3,707,687	DY	SPI	29	12	70	2	OYE LASER TUNABLE BY LONGITUDINAL DISPERSION IN DYE CELL
1096	A	3,654,567	MV	IBM	30	12	70	7	VAPOR OISCHRAGE CELL
1097	A	3,729,689	GA	CGE	30	12	70	21	TRAVELING WAVE EXCITED GAS LASER
1098	A	3,691,470	IN	BTL	31	12	70	16	DOUBLE HETEROSTRUCTURE LASER DIODES
1099	A	3,668,546	NS	PRV	11	1	71	5	LASER STIMULATOR ASSEMBLY
1100	A	3,679,998	NS	HAC	21	1	71	7	LASER FLASH TUBE TRIGGERING ARRANGEMENT

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUM8ER	TYPE LASER	HOLDS PAT	---DATE--- DA	MO	YR	NO. CLAIMS	PATENT DISCRIPTION
1101	A	3,648,192	SS	AFC	28	1	71	5	CW NONSPIKING SINGLE MODE LASER
1102	A	3,654,568	LQ	NVY	29	1	71	6	ROTATING LIQUID COOLED LIQUID LASER CELL
1103	A	3,688,218	AR	AMY	29	1	71	5	STIMULATED RADIATION CAVITY REFLECTOR
1104	A	3,775,699	NS	FLE	3	2	71	12	GAS FILLED FABRY PEROT ETALON MODE SELECTOR FOR LASER
1105	B	3,781,700	NS	LSU	11	2	71	17	AMPLIFYING IMAGE FORMING LIGHT RAYS
1106	A	3,703,687	NS	8TL	12	2	71	13	INTRACAVITY MODULATOR
1107	A	3,715,683	IO	RAY	19	2	71	11	COUPLED ION EYE SAFE LASER
1108	A	3,675,156	SS	BTL	25	2	71	4	LASER PUMP CAVITY WITH CONICAL GEOMETRY
1109	A	3,701, 46	GA	HAC	5	3	71	32	GAS LASER MATERIALS AND SYSTEM THEREFOR
1110	A	3,711,787	SS	AOC	10	3	71	8	ND GLASS LASER HAVING ROOM TEMP OUTPUT LESS THAN 1060 NM
1111	A	3,668,547	GA	SAB	10	3	71	7	FREQUENCY STABILIZED LASER ARRANGEMENT
1112	A	3,719,901	SS	RAY	12	3	71	12	LASER WITH MONOCRYSTALLINE YALO ND ACTIVE MEDIUM
1113	H	3, 27,694	IN	CRA	15	3	71	7	REISSUE 3537029 SEMI LASER EMTTNG AT 2 WAVELENGTHS SIMUL
1114	A	3,764,934	AR	PTG	17	3	71	11	LASER APPARATUS AND MIRROR ADJUSTMENT MECHANISM THEREFOR
1115	A	3,717,825	LQ	CZS	19	3	71	8	LIQUID LASER
1116	A	3,680, 0	NS	BTL	19	3	71	5	LASER CAVITY USING CONCAVE AND CONVEX MIRRCRS
1117	D	3,771, 67	GA	SAB	25	3	71	4	LASER FOR USE IN OPERATIONS WITH EXPLOSICN HAZARD
1118	C	3,760,292	SS	BTL	25	3	71	12	INTEGRATED FEED8ACK LASER
1119	D	3,750, 50	SS	OII	26	3	71	9	LASER ASSEM8LY
1120	A	3,735,284	GD	PRV	29	3	71	15	AERODYNAMIC LARGE VOL ELECTRIC DISCHARGE SYSTEM
1121	A	3,725,809	SS	BTL	5	4	71	4	DIELECTRIC RING LASERS USING WAVE GUIDING
1122	A	3,775,700	GA	CWD	6	4	71	9	GAS LASER
1123	A	3,711,790	SS	PRV	7	4	71	2	SEGMENTED GLASS LASER
1124	8	3,745,476	NS	UAC	8	4	71	5	LIGHT AMPLIFICATION USING A8SOR8ING MEDIUM
1125	A	3,715,684	GA	CGE	9	4	71	11	DOPED SEMICONDUCTOR WINDOW FOR LASER TU8E END PIECE
1126	A	3,660,777	GA	NVY	16	4	71	12	LASER PULSE TIME MODULATION Q SWITCH
1127	A	3,731,227	GA	SA8	23	4	71	9	GAS LASER EMPLOYING METALLIC VAPOR
1128	A	3,725,810	LQ	BTL	23	4	71	15	OPTICAL STIMULATED EMISSION DEVICES USING SPLIT OPT GUIDE
1129	A	3,675,157	DY	8TL	27	4	71	12	TUNABLE LASER IN A SENSITIZED TRANSPARANT MATERIAL
1130	A	3,721,916	GA	TRW	28	4	71	5	COLD CATHODE CONSTRUCTION FOR GASEOUS LASER
1131	A	3,720,885	GD	NVY	30	4	71	10	TRANSVERSE FLOW CAR8ON DIOXIDE LASER SYSTEM
1132	C	3,715,685	IN	8TL	30	4	71	12	HIGH EFFICIENCY INJECTION LASER CAVITIES
1133	Q	3,711,791	NS	PRV	3	5	71	8	FRUSTRATED TOTAL INTERNAL REFLECTION Q SWITCH
1134	X	3,772,612	MD	RCA	13	5	71	3	LIGHT MODULATOR
1135	M	3,723,903	IN	8TL	13	5	71	14	FM CONTROL OF TM MODES OF SELF PULSING SEMICONDUCTOR LAS
1136	A	3,680, 1	IN	8TL	13	5	71	14	DYNAMIC AM CONT OF TM MODES OF SELF PULSE SEMI LASER
1137	A	3,787,779	DY	TCS	14	5	71	1	ADJUSTABLE WAVELENGTH OPT SOURCE USEING STIM EMISSION EFF
1138	C	3,789,318	DY	CSF	14	5	71	3	SOURCE WITH ADJUSTA8LE WAVELENGTH
1139	A	3,701,956	NS	TRW	14	5	71	10	METH FOR GEN ULTRA SHORT TIME DURATION LASER PULSES
1140	8	3,747, 4	NS	AFC	14	5	71	3	INJECTION-LOCKED LASER STABILIZER
1141	A	3,694,765	NS	TRW	17	5	71	4	LOW LOSS LASER Q SWITCH
1142	A	3,719,900	GA	PRV	19	5	71	6	ULTRASTA8LE SYMMETRICAL LASER STRUCTURES
1143	F	3,679,994	IN	8TL	20	5	71	8	BROAD8AND OPTICALLY PUMPED SEMICONDUCTIVE LASERS
1144	A	3,681,710	GA	UAC	21	5	71	4	GAS LASER EMPLOYING MAGNETOGASDYNAMICS
1145	A	3,725,812	SS	TEX	26	5	71	14	LASER SYSTEM MOVING ELECTRONICALLY SELECTA8LE GAIN
1146	A	3,713, 42	NS	8TL	27	5	71	9	STA8ILIZED MODE LOCKED LASER ARRANGEMENT
1147	A	3,686,585	GA	PRV	27	5	71	10	METHOD OF STABILIZING A GAS LASER
1148	A	3,736,524	DY	EAK	1	6	71	9	LASER MEDIA CONTAINING FLOURINATED ALCOHCLS
1149	A	3,743,962	SF	BTL	1	6	71	2	THIN FILM RING LASERS
1150	C	3,750, 45	SS	BTL	1	6	71	4	LOGITUDINAL MODE STABILIZATION IN LASERS

LIST OF LASER PATENTS IN ORDER OF OATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLOS PAT	---OATE--- DA	MO	YR	NO. CLAIMS	PATENT OISCRIPTION
1151	A	3,697,8B8	NS	8TL	1	6	71	8	EVANESCENT WAVE COUPLING TECHNIQUE FOR BEAM SHAPING
1152	A	3,747, 17	SS	PRV	3	6	71	7	ENERGY CONVERTER SURFACE LASER ANO METHODS FOR OPERATION
1153	A	3,7B4,92B	GA	RCC	4	6	71	11	GAS OISCHARGE OEVICE AND ELECTROOE FOR USE THERE IN
1154	A	3,784,927	GA	PTG	11	6	71	8	GAS LASER
1155	A	3,764,935	NS	PRV	16	6	71	5	LASER PUMP ENCLOSURE
1156	A	3,766,4BB	DY	8TL	17	6	71	1	DYE LASER WITH PUMP CAVITY MODE MATCHED TO RESONATOR
1157	A	3,721,917	NS	USR	17	6	71	4	GAS OISCHARGE OEV FOR OPTICAL PUMPING OF LASERS
1158	A	3,731,224	NS	BTL	17	6	71	6	COMPENSATEO FOLDING RESONATOR
1159	A	3,781,707	SS	WEC	21	6	71	14	CALCIUM CONTAINING SILICATE GXYAPATITE LASERS
1160	A	3,710,273	SS	WEC	21	6	71	10	CALCIUM YTTRIUM SILICATE OXYAPATITE LASERS
1161	A	3,725,B13	GA	NIP	21	6	71	6	GAS LASER TU8E WITH ROD SHAPEO MEMBERS
1162	A	3,739,297	GA	RCA	21	6	71	6	SINGLE BORE TU8E GAS LASER
1163	A	3,686,5B6	SS	WEC	21	6	71	16	OXYAPATITE LASERS
1164	A	3,735,283	SS	TRW	23	6	71	4	BEAM DIAMETER CONTROL FOR PULSED LASER
1165	A	3,764,936	NS	SAB	25	6	71	10	ARRNGMT FOR CREATING A STA8LE PULSE WITH SHORT PULSE SPAC
1166	A	3,694,767	IO	BTL	25	6	71	10	BROAD SPECTRUM SELENIUM ION LASER
1167	A	3,699,470	IO	TRW	6	7	71	9	ELECTROSTATIC GAS 8YPASS FOR ION LASERS
1168	A	3,743,965	SS	SPI	12	7	71	22	TUNABLE LASERS
1169	A	3,699,471	GO	UAC	20	7	71	4	STRAY RADIATION SUPPRESSION DEVICE
1170	A	3,757,251	GD	UAC	21	7	71	4	DC AUX IONIZATION OF AXIAL EXCITEO FLOWING GAS LASER
1171	A	3,790,89B	GA	NAR	21	7	71	12	SELECTIVELY TUNABLE GASEOUS LASER
1172	A	3,758,876	GA	SA8	26	7	71	11	CARBON OIOXIDE LASER
1173	H	3,733,561	IN	BTL	27	7	71	12	HIGH POWER FUND TM MCDE OPERATION IN DOUBLE HETERO LASERS
1174	G	3,753,149	GA	SAB	29	7	71	10	GAS LASER
1175	A	3,731,221	CH	AFC	10	8	71	2	TUNABLE OPTICAL CAVITY FOR CHEMICAL LASER
1176	A	3,735,280	SS	BTL	11	8	71	6	WHITE LIGHT LASER USING OYE COUPLING ANO PUMP DIODES
1177	A	3,777,280	NS	IBM	12	3	71	19	LASER GENERATOR OF TE WAVE GUIOE MOOES
1178	H	3,747, 16	IN	RCA	26	B	71	B	SEMICONOUCTOR INJECTICN LASER
1179	H	3,725,B14	NS	AFC	10	9	71	6	APP FOR LOCKING FREQ TO ATOMIC ABSORPTION LINE
1180	H	3,750, 46	IN	8TL	13	9	71	6	SILVER OCPED CADMIUM TIN PHOSPHIDE LASER
1181	A	3,75B,B74	CD	AVC	17	9	71	1	CORCNA OISCHARGE LASER
1182	A	3,717,823	GA	SPR	20	9	71	4	METAL GLASS LASER WINCOW ASSEMBLY
1183	A	3,731,223	NS	BTL	23	9	71	6	LASER APPARATUS FOR OPTICAL MODULATION TRANSFER
1184	F	3,702,972	GA	NAS	23	9	71	10	HYDROGEN MASER WITH 8UL8 TEMP CONTROL
1185	A	3,7B1,710	GA	CGE	24	9	71	2	GAS LASER GENERATOR OEVICE
11B6	A	3,772,608	NS	AMY	27	9	71	2	CHARGEO PARTICLE TRIGGERED OISCHARGE FOR A LASER
11B7	A	3,760,294	GA	AMY	27	9	71	4	THERMAL MIXING GAS LASER
11B8	C	3,789,317	IN	ZHH	27	9	71	5	SIGNAL CONVERTER WHEREIN PHOTOEMISSION TIME CONST IS USED
11B9	A	3,755,756	GA	BTL	30	9	71	12	GAS LASER EMPLOYING SEGMENTED DISCHARGE TUBE
1190	A	3,786,366	NS	PRV	1	10	71	27	SUPER RAOIENT LASER ILLUMINATOR ANO IMAGE AMPLIFIER
1191	A	3,704,42B	GA	AFC	4	10	71	8	CO LASER FROM HELIUM AIR METHANE MIXTURE
1192	H	3,761,B37	IN	BTL	8	10	71	1	INDIRECT GAP CRYSTALS DOPEO WITH ISOELECTRONIC TRAPS
1193	A	3,701,957	SS	TRW	12	10	71	6	COHERENCE CONTROLLEO RUBY LASER
1194	A	3,753,144	GA	PRV	1B	10	71	3	GAS LASER STRUCTURE
1195	A	3,753,146	DY	EAK	18	10	71	13	NOVEL VISI8LE SPECTRUM DYE LASERS
1196	C	3,786,367	NS	BDX	19	10	71	4	HOLCGRAPHIC SYSTEM
1197	A	3,727,150	SS	ACC	22	10	71	10	YTTERBIUM GLASS LASER WITH OUTPUT IN 1024 NM RANGE
119B	X	3,748,597	NS	8TL	2B	10	71	16	OPTICAL MODULATORS USING SEMICONDUCTIVE BODY *****
1199	A	3,706, 50	GD	AMY	2	11	71	5	MAGNETOHYDRODYNAMIC GAS DYNAMIC LASER
1200	A	3,742,378	GA	PHL	3	11	71	5	IRASER USING CO2 NITROGEN HE WATER VAPOR AND ZEOLITE

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	---DATE--- DA	MO	YR	NO. CLAIMS	PATENT DISCRIPTION
		3,719,899	GA	PRV	4	11	71	6	STABILIZED OPTIMIZABLE GASEOUS ELECTRICAL DISCHARGE
1201	A	3,731,226	SS	AOC	10	11	71	5	LASER USING PHOSPHATE 8ASE LASER GALSS
1202	A	3,702,976	SS	AOC	11	11	71	7	ALL GLASS PERIPHERALLY MULTI ARCUATE DISC LASER
1203	A	3,699,474	NS	AEC	20	11	71	7	MULTIPLE BEAM LASER SYSTEM
1204	A	3,766,466	SS	NVY	26	11	71	3	Q SWITCHING SEVERAL INOEPENDENT RUBY LASERS
1205	A	3,747, 20	IN	IBM	26	11	71	24	POLARIZATION JUNCTION LASER
1206	A	3,790,900	GA	SAB	29	11	71	3	GAS LASER MIRROR ASSEM8LY
1207	A	3,717,824	GA	UAC	2	12	71	10	MAGNETICALLY SCAN ELECTRIC DISCHARGE GAS LASER
1208	A	3,736,525	GA	RCA	6	12	71	11	UNITIZED INTERNALLY MCOULATEO GAS LASER
1209	A	3,743,970	NS	BTL	6	12	71	14	UNITIZED INTERNALLY MCOULATEO GAS LASER
1210	A	3,744,121	OY	8TL	13	12	71	7	TEO ACOUSTOOPTIC LIGHT OETECTOR
1211	A	3,774,121	NS	BTL	13	12	71	7	WAVELENGTH SELECTIVE APPARATUS
1212	A	3,706, 46	NS	BTL	27	12	71	5	WAVELENGTH SELECTIVE LASER USING PUMPED DYE CELL
1213	A	3,772,611	GA	UAC	7	1	72	3	PHASE LOCKEO SIGNAL SOURCE
1214	A	3,761,836	GD	UAC	13	1	72	2	WAVEGUIOE GAS LASER DEVICES
1215	A	3,747, 15	GD	ISE	20	1	72	2	MAGNETICALLY COMPENSATED CROSS FIELD FLOWING GAS LASER
1216	A	3,760,297	IN	AEC	2	2	72	15	MAGNETICALLY STA8 CROSS FIELO FLOWING GAS LASER
1217	A	3,753,152	GA	NVY	3	2	72	20	LASER TO OPTICAL FI8ER COUPLING
1218	A	3,777,282	MV	CRL	4	2	72	6	ELECTRICAL PUMPEO PULSEO LASER
1219	A	3,783,405	NS	8TL	7	2	72	15	METAL VAPOR LASER TU8E
1220	A	3,766,489	DY	NVY	9	2	72	5	MEANS FOR OEFOGGING LASER OPTICAL CAVITY
1221	A	3,743,961	GA	AEC	15	2	72	4	OYE LASER EMFLOYING FREE FLOWING LIQUIO STREAM
1222	A	3,757,249	NS	UAC	22	2	72	9	INCLINED AIR CORE SOLENOIO FIELOS FOR LASERS
1223	A	3,740,664	NS	NVY	24	2	72	4	Q SWITCHEO MODE LOCKED LASER OSCILLATOR
1224	A	3,760,293	FL	AMY	14	3	72	1	HYBRIO FREQUENCY STABLE LASER SYSTEM
1225	A	3,766,490	SS	BTL	15	3	72	5	CONTINOUS WAVE FREE 8URNING FLAME LASER
1226	A	3,754,195	DY	AVC	16	3	72	7	LU NO YAG LASER SYSTEM AND MATERIAL
1227	A	3,740,665	LQ	MMM	16	3	72	10	OOUBLE FOLOEO ASTIGMATICALLY COMPENSATED OPTICAL CAVITIES
1228	A	3,747, 18	IN	IBM	20	3	72	26	TRANSVERSE FLOWING LIQUID LASER
1229	A	3,743,964	NS	PFC	22	3	72	9	PLATELET SEMICONDUCTIVE LASER
1230	A	3,790,901	GA	GSY	28	3	72	1	Q SWITCHING SATURABLE A8SORBER DYE FOR A LASER
1231	A	3,774,124	NS	GSY	28	3	72	1	ELECTRO-OPTICALLY INDUCEO WEAK COUPLING CF CO2 MODES
1232	A	3,744,124	MO	USR	29	3	72	8	INCOHERENT TO COHERENT IMAGE CONVERTER
1233	A	3,728,640	NS	UAC	30	3	72	12	INCOHERENT TO COHERENT IMAGE CONVERTER
1234	A	3,777,279	GA	EAK	30	3	72	4	OPEN TYPE RESONATOR
1235	A	3,731,222	DY	BTL	3	4	72	2	DEPOSITION OF POWER IN A MOVING GAS STREAM BY ELECT MEANS
1236	A	3,739,295	NS	BTL	3	4	72	20	PHENOXAZINE DYE LASERS
1237	A	3,742,382	NS	IBM	6	4	72	8	MEANS FOR SUPPRESSING BACKGROUND FLOURESCENCE IN OUTPUT
1238	A	3,766,498	NS	NAS	6	4	72	14	STABILIZING A LASER TO A GAS ABSORPTION LINE
1239	A	3,753,148	DY	BTL	21	4	72	8	METHOO FOR PRODUCING EM TRANSIENT COHERENT EFFECTS
1240	A	3,766,491	GA	PRV	21	4	72	10	INFRAREO TUNABLE LASER
1241	A	3,777,283	XX	HAC	26	4	72	6	RADIATION AND PRESSURE 8ROAD TECH FOR SINGLE FREQ LASERS
1242	A	3,786,365	SS	UAC	26	4	72	4	TRANSPARENT SLIDE FOR EXAMINATION OF LIQUID SPECIMENS
1243	A	3,764,937	GA	AFC	28	4	72	8	RADIATION EXPANDEO LATTICE STRUCTURES
1244	A	3,725,816	GA	AEC	8	5	72	10	LASER MATLS USING RARE EARTH
1245	A	3,789,319	GA	NAS	9	5	72	10	FREQ CONTROLLED PASSIVELY Q SWITCHEO LASER
1246	A	3,758,877	NS	AFC	17	5	72	3	FAN GEOMETRY MIXING LASER
1247	A	3,769,608	OY	AFC	17	5	72	2	HYOROGEN ROTATION-VI8RATION OSCILLATOR
1248	A	3,713, 44	GA	AFC	17	5	72		POWER SUPPLY FOR CO2 LASER
1249	A	3,750, 48							ULTRA HIGH FREQ MECHANICAL Q SWITCH
1250	A								N2 PUMPEO TUNABLE DYE LASER
									WINDOW FOR HIGH POWER GASEOUS LASERS

LIST OF LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	TYPE LASER	HOLDS PAT	DATE DA	DATE MO	DATE YR	NO. CLAIMS	PATENT DISCRIPTION
1251	A	3,735,2B1	GA	PHL	19	5	72	5	GAS DISCHARGE LASER
1252	A	3,760,295	SS	IBM	22	5	72	6	Q SWITCH FOR SYNC MODE LOCKED LASER PULSE WITH EXT EVENTS
1253	Y	3,753,151	SS	PHL	2	6	72	4	MODE SELECTOR FOR SCAN LASER
1254	A	3,732,505	NS	AFC	7	6	72	2	END PUMP DEVICE FOR LASER USING LED SYSTEM
1255	A	3,763,441	IN	SAB	12	6	72	8	DEVICE FOR PHASE SYCHRONIZATION OF SEVERAL LASER OSCILTRS
1256	A	3,745,4B1	GA	AEC	13	6	72	4	ELECTRODES FOR ELECTRICALLY PUMPED GAS LASERS
1257	D	3,768, 34	GA	PHL	14	6	72	3	GAS DISCHARGE LASER
125B	A	3,735,282	SS	PRV	14	6	72	3	LIQUID COOLED SEGMENTED GLASS LASER
1259	A	3,7B3,406	NS	TRW	19	6	72	5	LASER Q SWITCHING
1260	A	3,7B5,320	GA	FLE	19	6	72	5	GAS LASER CIRCULATION SYSTEM
1261	A	3,748,594	GD	AVC	22	6	72	4	RADIO FREQUENCY ELECT EXCITED FLOWING GAS LASER
1262	C	3,757,247	TW	NVY	22	6	72	4	FREQUENCY SELECTIVE OPTICAL ISOLATOR
1263	A	3,753,147	SS	UCC	23	6	72	8	LASER OSCILLATOR AMPLIFIER SYSTEM
1264	A	3,755,757	SS	AOC	23	6	72	7	HIGH EFFICIENCY ERBIUM GLASS LASER
1265	M	3,760,296	GA	RCA	26	6	72	8	INTERNALLY MOUNTED GAS LASER
1266	A	3,753,145	SS	BTL	26	6	72	10	COMPACT END PUMPED SOLID STATE LASER
1267	A	3,772,609	NS	AMY	30	6	72	3	LASER CAVITY CONFIGURATION YIELDING DUAL OUTPUT BEAM
126B	D	3,763,442	IO	ALC	7	7	72	2	ION LASER PLASMA COOLING DEVICE AND METHOD
1269	A	3,757,246	GA	CZS	12	7	72	7	ENERGY STORER AND DISCHARGE CHAMBER FOR A GAS LASER
1270	A	3,7B7,7B0	NS	RCA	24	7	72	8	TUBE HAVING INTRNAL GLASS MEMBER COATED WITH CERAMIC MATL
1271	A	3,766,492	NS	AMY	25	7	72	16	LASER PUMPING SYSTEM
1272	A	3,757,248	GA	MIT	31	7	72	16	PULSED GAS LASER
1273	A	3,7B1,709	GA	SAB	2	8	72	5	LASER ARRANGEMENT
1274	A	3,679,997	GA	QGH	4	8	72	12	NOBLE GAS MOLECULAR NITROGEN LASER
1275	A	3,736,526	NS	TRW	7	B	72	3	GENERATING ULTRA SHORT TIME DURATION LASER PULSES
1276	L	3,771, 65	DY	NVY	9	8	72	6	TUNABLE INTERNAL FDBK LIQ CRYSTAL DYE LASER
1277	A	3,763,443	SS	BTL	14	B	72	5	SIMULTANEOUSLY Q SWITCHED AND MODE LOCKED LASER
1278	P	3,787,781	GA	AFC	17	B	72	2	EXTERNAL CATHODE INTERNAL ANODE FIGURE EIGHT LASER
127S	Z	3,750, 47	GA	AEC	25	8	72	3	GAS LASER HAVING EXCITATION CHAMBERS WITH MULT WINDOWS
1280	C	3,790,902	IN	BTL	5	9	72	10	FUNDAMENTAL TRANSVERSE MODE OPERATION
12B1	A	3,753,150	GA	ANC	6	9	72	18	LASER MIRROR POSITIONING APPARATUS
12B2	B	3,789,310	GA	AEC	14	9	72	3	HIGH-EMISSION COLD CATHODE
12B3	A	3,789,321	GA	AEC	14	9	72	5	ELECTRON BEAM PUMPED GAS LASER SYSTEM
12B4	A	3,772,610	GA	GSY	20	9	72	11	ARCLESS ELECTRODE CONSTRUCTION FOR GAS TRANSPORT LASER
12B5	A	3,768, 35	GD	AVC	22	9	72	11	MODULAR AERODYNAMIC LASER WINDOW
12B6	A	3,7B3,403	SS	TRW	22	9	72	5	DOUBLE PULSE LASER
12B7	A	3,766,493	SS	NVY	26	9	72	8	HOLDING CLADDING FOR LASER SLABS
12BB	C	3,783,407	NS	CRL	26	9	72	1B	IMPROVED LASER OPTICAL RESONATOR
12B9	A	3,774,122	DY	EAK	6	10	72	10	BRIDGED CYANINE DYE LASERS
1290	A	3,781,711	DY	EAK	16	10	72	B	LASER DYE COMPOSITION
1291	A	3,7B1,712	GA	HAC	17	10	72	12	LASER WITH DISCHARGE CONDITIONING USING UV PHOTONS
1292	A	3,786,36B	NS	BTL	20	10	72	5	PLANAR WAVEGUIDE DIST FEEDBACK LASER WITH ANGULAR TUNING
1293	A	3,784,929	SS	RCA	30	10	72	7	THERMALLY-CONTROLLED CRYSTALLINE LASERS
1294	A	3,7B1,713	GA	AFC	7	11	72	6	CARBON MONOXIDE LASER BY ACETYLENE OXIDATION
1295	A	3,7B6,369	DY	EAK	27	12	72	7	LASER DYE COMPOSITION
1296	A	3,725,815	SS	PRV	10	12	72	6	PHOTOELASTIC MODE LOCKING USING BIREFRINEENT CRYSTALS
1297	A	3,7B1,714	NS	AFC	5	2	73	5	ISOLATOR FOR HIGH POWER LASER SYSTEM
1298	A	3,7B6,370	NS	AFC	1	5	73	6	SPACEBORNE SUN PUMPED LASER

LIST OF SEMICONDUCTOR LASER PATENTS IN ORDER OF DATE APPLIED

INDEX NO.	SEARCH CLASS	PATENT NUMBER	HOLDS PAT	---DATE--- DA	MO	YR	NO. CLAIMS	PATENT DISCRIPTION
1	A	3,265,990	I8M	15	10	62	13	STIMULATED EMISSION OF RADIATION IN SEMICONDUCTOR DEVICES
2	A	3,245, 2	GEC	24	10	62	10	STIMULATED EMISSION SEMICONDUCTOR DEVICES
3	A	3,248,669	IBM	30	10	62	1	SEMICONDUCTOR LASER WITH OPTICAL CAVITY
4	X	3,387,230	I8M	30	10	62	10	STRESS MODULATION OF RECOM8INATION RADIATION IN SEMICOND
5	A	3,248,670	IBM	30	10	62	15	SEMICONDUCTOR LASER WITH OPTICAL CAVITY
6	A	3,248,671	IBM	30	11	62	1	LASERS USING INTERNAL REFLECTION TECHNQIUES
7	A	3,341,787	TEX	3	12	62	1	LASER SYS WITH PUMPING 8Y SEMICOND RADIANT DIODE
8	A	3,257,626	IBM	31	12	62	9	SEMICONDUCTOR LASER STRUCTURES
9	A	3,258,718	MIT	7	2	63	1	SEMICONDUCTOR INFRARED MASER
10	A	3,284,722	RCA	22	3	63	10	LIGHT COUPLING DEVICE
11	A	3,456,209	PHL	22	3	63	12	USE OF REFRACTIVE INDEX GRADIENT TO CONFINE LASER BEAM
12	A	3,354,406	RCA	22	4	63	5	ELEMENT AND APPARATUS FOR GENERATING COHERENT RADIATION
13	B	3,247,459	PHL	3	5	63	2	PLURAL LASER AMPLIFIERS IN TANDEM
14	A	3,312,910	PRV	6	5	63	3	FM MODULATION OF EMITTING PN JUNCTION
15	A	3,704,427	SAB	7	6	63	23	DEVICE FOR STIMULATING EMISSION OF RADIATION FROM A DIODE
16	A	3,340,479	BTL	14	6	63	2	LASER TUNABLE BY JUNCTION COUPLING
17	A	3,363,195	8TL	1	7	63	9	JUNCTION DIODE MASER
18	A	3,393,373	PRV	11	7	63	2	ELECTRON STIMULATED OPTICAL MASER
19	A	3,353,114	80E	9	9	63	14	TUNNEL INJECTION LIGHT EMITTING DEVICE
20	A	3,412,344	RCA	30	10	63	8	SEMICONDUCTOR PLASMA LASER
21	A	3,382,454	RAY	12	11	63	8	LOW LOSS INJECTION LASER
22	A	3,361,988	8TL	9	12	63	5	LASER MATRIX DEVICE
23	A	3,287,659	80E	12	12	63	13	SIGNAL GENERATOR USING SEMICNDTR MATL IN MAG AND EL FIELD
24	A	3,510,795	SHA	13	12	63	19	INTEGRAL HEAT SINK IN A LASER DIODE
25	A	3,281,714	I8M	31	12	63	1	INJECTION LASER USING MINORITY CARRIER TUNNELING
26	B	3,317,848	I8M	20	1	64	6	NON-RECIPRCCAL LIGHT AMPLIFIER
27	A	3,303,431	IBM	10	2	64	9	COUPLED SEMICONDUCTOR INJECTION LASER DEVICES
28	A	3,359,507	GEC	19	2	64	11	SEMICONDUCTOR JUNCTION LASER DEVICE
29	A	3,359,508	GEC	19	2	64	7	HIGH POWER JUNCTION LASER STRUCTURE
30	A	3,359,509	GEC	19	2	64	6	JUNCTION LASER WITH TEMPERATURE COMPENSATION
31	X	3,482,189	GEC	24	3	64	3	FREQ CONTRCL BY APPLICATION CF FORCE
32	A	3,484,713	GEC	3	4	64	9	TWO STAGE SEMICONOUCTOR COHERENT RADIATION SOURCE
33	X	3,518,574	I8M	1	5	64	10	INJECTION LASER DEVICE
34	A	3,427,563	IBM	13	5	64	17	MULTISTABLE OEVICE OPERATING ON PRINCIPLE OF STIM EMISSN
35	A	3,431,512	UCC	29	6	64	2	JUNCTION LASER WITH CONTROLLED OUTPUT
36	A	3,423,694	MEL	26	8	64	11	RADIANT ENERGY SOURCE
37	X	3,504,302	GEC	24	9	64	4	FREQUENCY CONTROLLED SEMICONDUCTOR JUNCTION LASER
38	A	3,431,513	NIP	28	9	64	1	TWIN SEMICONDUCTOR LASER
39	X	3,331, 36	BTL	5	10	64	3	OPTICAL WAVE MODULATORS AND ATTENUATORS
40	A	3,396,344	NRD	18	2	65	10	SEMICONDUCTOR LASER ARRAY
41	A	3,402,366	I8M	26	2	65	9	BEAM SCANNING IN INJECTION LASERS
42	A	3,439,289	AFC	8	7	65	1	SEMICONDUCTOR LASER COMPONENTS FOR DIGITAL LOGIC
43	A	3,368, 87	MIT	16	7	65	1	OPTICALLY PUMPED SEMICONDUCTOR LASER
44	A	3,493,891	I8M	2	8	65	2	AVALANCHE BREAKDOWN SEMICONDUCTOR LASER
45	X	3,401,357	8TL	11	8	65	8	ELECTROMAGNETIC WAVE AMP,OSCILLATOR AND MODULATOR
46	A	3,484,716	GEC	1	10	65	8	HIGH DUTY CYCLE LASER DEVICE
47	A	3,483,480	NIP	19	10	65	4	SEMICONDUCTOR COMPOUND LASERS
48	X	3,768, 37	HIT	26	11	65	8	SEMICONDUCTOR DIODE LASER DEVICE
49	A	3,448,405	8TL	17	2	66	7	SCANNING LASER
50	A	3,436,679	GEC	7	3	66	20	LASER WITH ELECTRONICALLY DISPLACEA8LE AND DEFLECT8L BEAM

LIST OF SEMICONDUCTOR LASER PATENTS IN ORDER OF DATE APPLIED

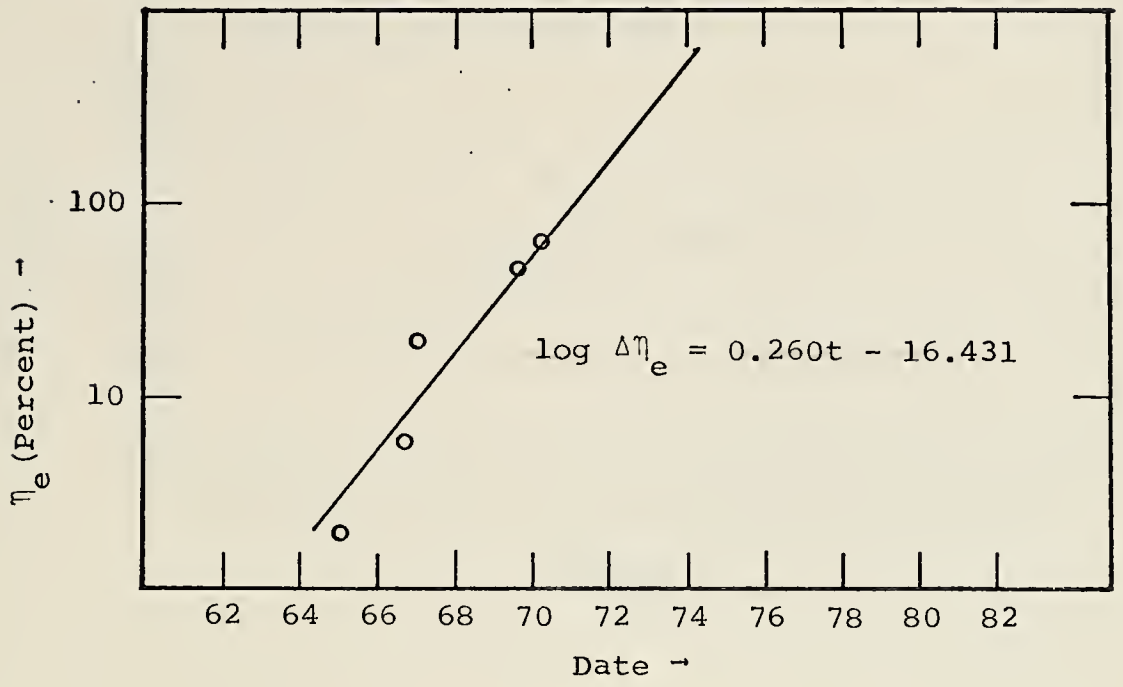
INDEX NO.	SEARCH CLASS	PATENT NUMBER	HOLDS PAT	DATE DA	DATE MO	DATE YR	NO. CLAIMS	PATENT DISCRIPTION
51	A	3,303,432	GEC	18	4	66	17	HIGH POWER SEMICONDUCTOR LASER DEVICES
52	AX	3,531,735	GEC	28	6	66	4	GROOVES TO PREVENT RADIATION TRANSVERSE TO OPTIC AXIS
53	AX	3,551,848	GIC	30	6	66	3	LASER MODULATING SYSTEM
54	A	3,701, 47	RCA	16	8	66	3	SEMICONDUCTOR DEVICE WITH LIGHT REFLECT METALLIC LAYERS
55	X	3,478,280	GEC	14	10	66	7	PULSE WIDTH MODULATED LASER
56	AX	3,510,799	KDD	27	10	66	5	LASER ELEMENT WHICH PERFORMS LOGICAL OPERATIONS
57	XA	3,483,487	8TL	29	12	66	8	STRESS MODULATION OF RAD WITH WIDE FREQ TUNING RANGE
58	A	3,534,290	GEC	1	2	67	10	8EACON FOR ROTATING AN OUTPUT 8EAM
59	A	3,576,501	IUP	7	3	67	3	LSR HAVING ROUGHENED N-ZONE JUST 8ELOW THE JUNCTION
60	B	3,506,925	SAB	14	3	67	24	GENERATING AND AMPLIFYING ULTRA HI-FREQ SIGNALS
61	A	3,479,614	8TL	23	3	67	3	TUNA8LE SEMICONDUCTOR MASERS
62	AA	3,522,552	ISE	18	4	67	6	SEMICONDUCTOR LASER UNIT
63	AA	3,479,613	NVY	28	4	67	5	LASER DIODE
64	AA	3,524,146	IUP	11	5	67	6	LSR HAVING 8REWSTER ANGLE FACE AND REMOTE REFLECTOR
65	8	3,467,906	RCA	14	6	67	7	CONSTANT GAIN LOW NOISE LIGHT AMPLIFIER
66	A	3,514,715	RCA	29	6	67	8	MULTILAYER LIGHT EMITTING SEMICONDUCTOR DEVICE
67	AA	3,560,873	TEX	5	7	67	4	OPTICALLY PUMPED HG DOPED GERMANIUM IN LIQUID HE DEWAR
68	AA	3,526,851	RCA	10	7	67	8	FILIMENTARY STRUCTURE LSR WITH VERY NARROW ACTIVE JUNCTN
69	A	3,614,661	TPV	27	7	67	15	ARRANGEMENT FOR EXCITING LIGHT WAVE CONDUCTORS
70	XA	3,462,711	8TL	28	8	67	8	ELECTRO-OPTIC DIODE MODULATORS
71	AA	3,585,520	HIT	13	9	67	8	PULSE TRIGGERED BY FORMATION AND TRANSIT OF HI FIELD DOM
72	AA	3,537, 28	RCA	23	10	67	8	CONFOCAL SEMICONDUCTOR DIODE LASER
73	AA	3,622,906	RCA	24	10	67	7	LIGHT EMITTING DIODE ARRAY
74	XA	3,517,337	I8M	26	10	67	5	MODULATION OF SCANNING 8EAMS IN INJECTION LASERS
75	AJ	3,551,842	RCA	27	3	68	8	LSR HAVING HIGH POWER OUTPUT AND REDUCED THRESHOLD
76	J	3,517,336	PRV	31	5	68	4	SINGLE ELEMENT THIN FILM OSCILLATOR (CODE IN NOT EXACT)
77	XA	3,477, 41	RCA	5	6	68	8	AMP MOD LIGHT 8Y SOLID STATE OSCILLATOR
78	A	3,537, 29	RCA	10	6	68	8	PRODUCING LIGHT A TWO WAVELENGTHS SIMULTANEOUSLY
79	AA	3,602,838	I8M	18	7	68	25	ELECTRON OR PHOTON 8EAM EXCITED SEMICONDUCTOR LASER
80	A	3,593,191	SA8	30	9	68	8	ELECTRICALLY FOCUSSED LASED DIODE
81	A	3,643,176	GTU	30	9	68	12	SUPERCODUCTOR ELECTROMAGNETIC DEVICE
82	AA	3,586,999	RCA	16	10	68	13	FIELD EXCITED LSR USING UNIFORM DOPED SINGLE CRYSTAL
83	AA	3,617,929	TEX	30	12	68	4	LASER HAVING MODE SUPPRESSING REGION
84	XA	3,539,945	AMY	25	3	69	3	MODULATION DIODES FOR MAXIMUM OPTICAL POWER
85	AA	3,624,549	8TL	16	4	69	16	INFRARED DIODE PUMPED VISI8LE LASER
86	A	3,593,190	TEX	16	4	69	12	ELECTRON 8EAM PUMPED LSR WITH ARRAY OF MOSAIC ELEMENTS
87	A	3,599,109	8TL	16	4	69	11	SECOND PHOTON VISI8LE EMITTING PHOSPHOR USED ON IR DIODE
88	A	3,605, 37	8TL	2	5	69	7	CURVED JUNCTION LASER DEVICE
89	AC	3,740,661	8TL	6	6	69	14	MINOR LO8E SUPPRESSION IN SEMICONDUCTOR INJECTION LASERS
90	X	3,663,897	IUP	6	6	69	11	MODULATING A LASER BEAM.
91	A	3,617,932	8TL	16	6	69	8	METHOD FOR PULSE WIDTH MODULATING SEMICONDUCTOR LASERS
92	A	3,636,471	MIT	3	7	69	21	ENHANCING RADIATION FROM INDIRECT GAP SEMICONDUCTORS
93	A	3,624,553	8TL	6	10	69	5	CYLOTRON LASER IN A P-TYPE SEMICONDUCTOR
94	A	3,641,459	8TL	1	12	69	13	NARROWING PW AND STAB PRR IN LASER WITH SELF INDUCED PULS
95	X	3,611,207	PRV	5	1	70	10	WIDE APERTURE ELECTROOPTIC MODULATOR
96	XA	3,691,483	PRV	9	2	70	5	PHASED ARRAY LASER SOURCE
97	A	3,701, 43	MDC	16	2	70	3	NEGATIVE RESISTANCE LIGHT EMITTING DIODE DEVICE
98	A	3,758,875	8TL	1	5	70	9	DOU8LE HETEROSTRUCTURE JUNCTION LASERS
99	N	3,657,826	NVY	25	5	70	7	SEMICONDUCTOR LASER MARKSMANSHIP TRAINING DEVICE
100	A	3,660,780	ISE	26	5	70	10	SEMICONDUCTOR LASERS

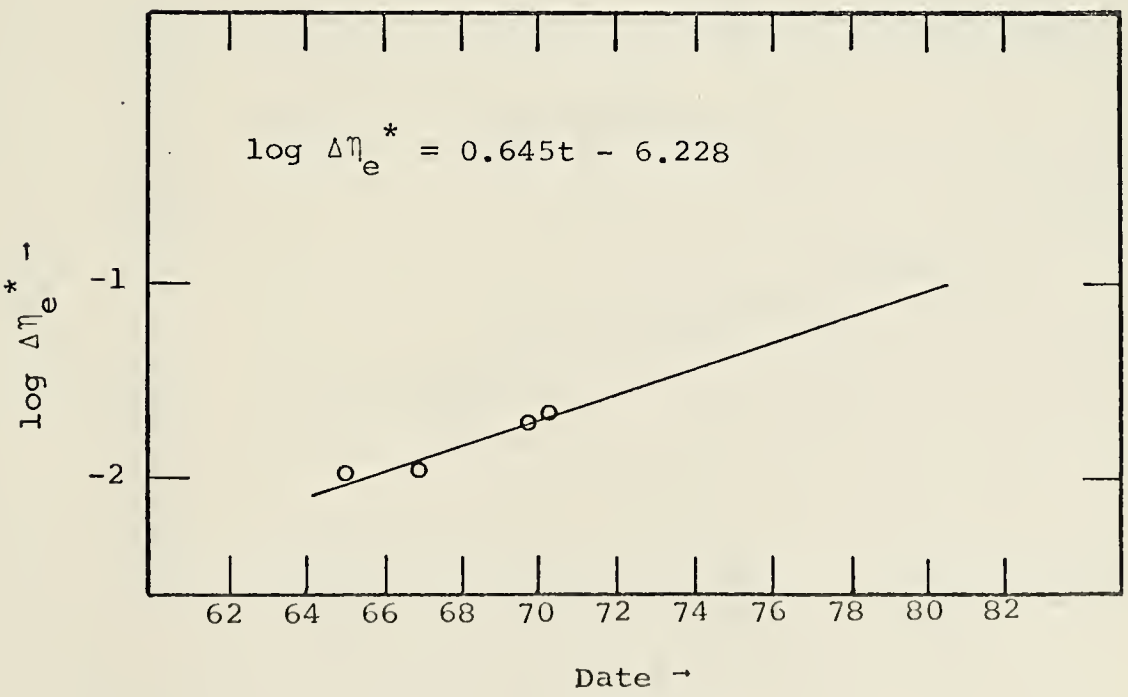
LIST OF SEMICONOUCTOR LASER PATENTS IN ORDER OF DATE APPLIED

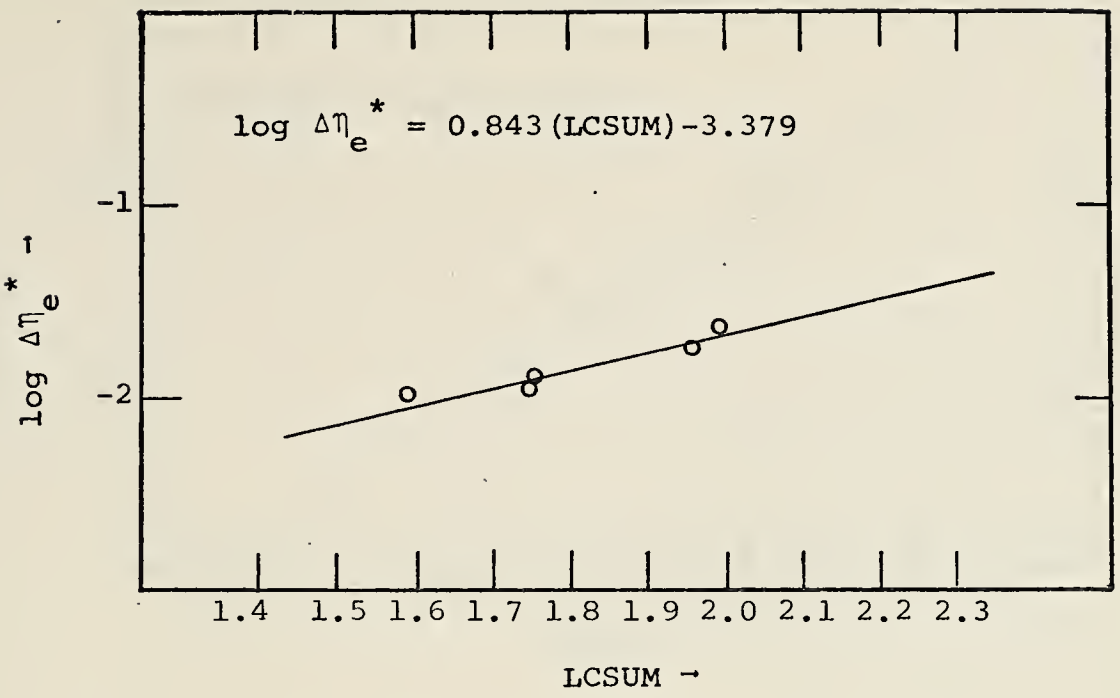
INDEX NO.	SEARCH CLASS	PATENT NUMBER	HOLDS PAT	---DATE--- DA	MO	YR	NO. CLAIMS	PATENT DISCRIPTION
101	A	3,701, 44	BTL	29	6	70	2	OPTICAL COUPLING OF ADJACENT STRIPE CONTACT SEMI LASERS
102	A	3,675,150	IBM	30	6	70	17	INTERNAL MOOULATION USING ACOUSTIC WAVES
103	D	3,704,377	III	10	7	70	7	LASER COMPRISING FRESNEL OPTICS
104	A	3,676,795	MIT	13	7	70	28	MULTIPLE FREQUENCY LASER APPARATUS AND METHOD
105	A	3,621,455	PRV	28	7	70	7	PINCH EFFECT LASER
106	A	3,696,310	BTL	1	10	70	22	MOOE LOCKING IN SEMICONOUCTOR LASERS
107	H	3,748,593	MIT	17	11	70	11	METHOD FOR CONSTRUCTION OF SEMICONDUCTOR MAIL FOR A LASER
108	P	3,711,789	TEX	18	11	70	18	OIOOE ARRAY ASSEMBLY FOR DIOOE PUMPED LASERS
109	H	3,702,975	BTL	9	12	70	1	LOW THRESHOLO STRIPE GEOMETRY INJECTION LASER
110	A	3,691,476	BTL	31	12	70	16	DOUBLE HETEROSTRUCTURE LASER OIOOES
111	H	3, 27,694	CRA	15	3	71	7	REISSUE 3537029 SEMI LASER EMITNG AT 2 WAVELENGTHS SIMUL
112	C	3,715,685	BTL	30	4	71	12	HIGH EFFICIENCY INJECTION LASER CAVITIES
113	M	3,723,903	BTL	13	5	71	14	FM CONTROL OF TM MODES OF SELF PULSING SEMICONOLCTOR LAS
114	A	3,680, 1	BTL	13	5	71	14	OYNAMIC AM CONT OF TM MOOES OF SELF PULSE SEMI LASER
115	F	3,679,994	BTL	20	5	71	8	BROADBANO OPTICALLY PUMPEO SEMICONOUCTIVE LASERS
116	H	3,733,561	BTL	27	7	71	12	HIGH POWER FUNO TM MOOE OPERATION IN DOUBLE HETERO LASERS
117	H	3,747, 16	RCA	26	8	71	8	SEMICONOUCTOR INJECTION LASER
118	H	3,750, 46	BTL	13	9	71	6	SILVER OOPED CADMIUM TIN PHOSPHIOE LASER
119	C	3,789,317	ZHH	27	9	71	5	SIGNAL CONVERTER WHEREIN PHOTOEMISSION TIME CONST IS USED
120	H	3,761,837	BTL	8	10	71	1	INOIRECT GAP CRYSTALS DOPEO WITH ISOELECTRONIC TRAPS
121	C	3,747, 20	IBM	26	11	71	24	POLARIZATION JUNCTION LASER
122	A	3,760,297	ISE	20	1	72	15	LASER TO OPTICAL FIBER COUPLING
123	A	3,747, 18	MMM	16	3	72	10	PLATELET SEMICONOUCTIVE LASER
124	A	3,763,441	SAB	12	6	72	8	OEVICE FOR PHASE SYCHRONIZATION OF SEVERAL LASER OSCILTRS
125	C	3,790,902	BTL	5	9	72	10	FUNOAMENTAL TRANSVERSE MOOE OPERATION

APPENDIX B

GRAPHS FOR RATE OF PARAMETER PROGRESS DATA



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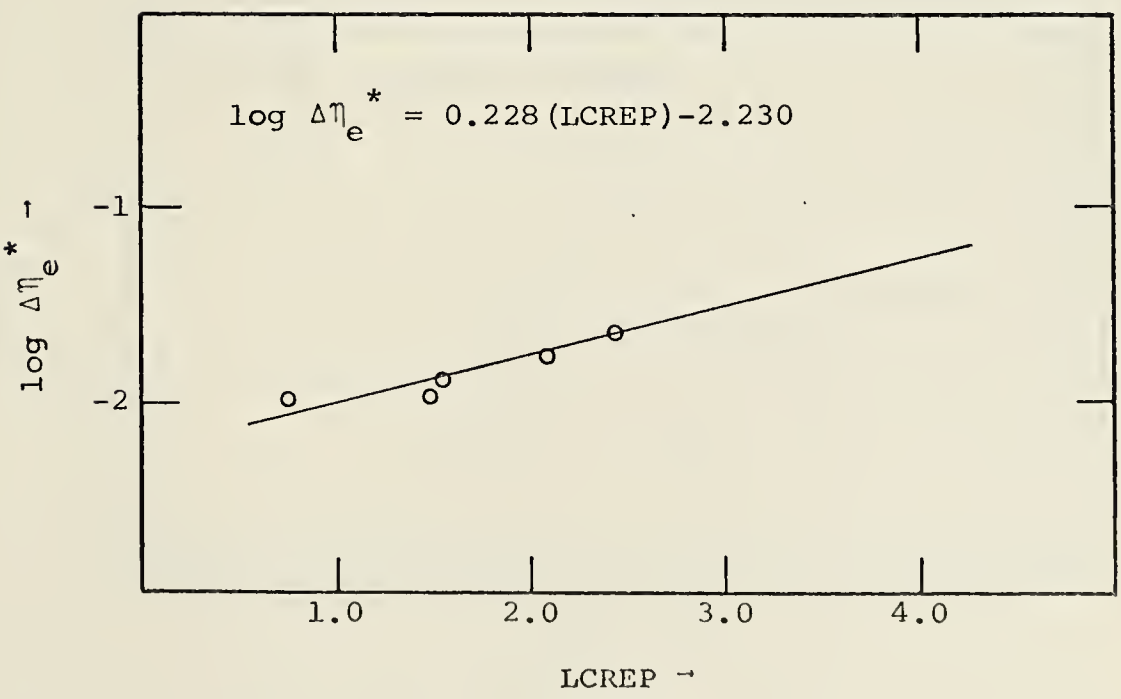
-2
1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3
LCSUM →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-2
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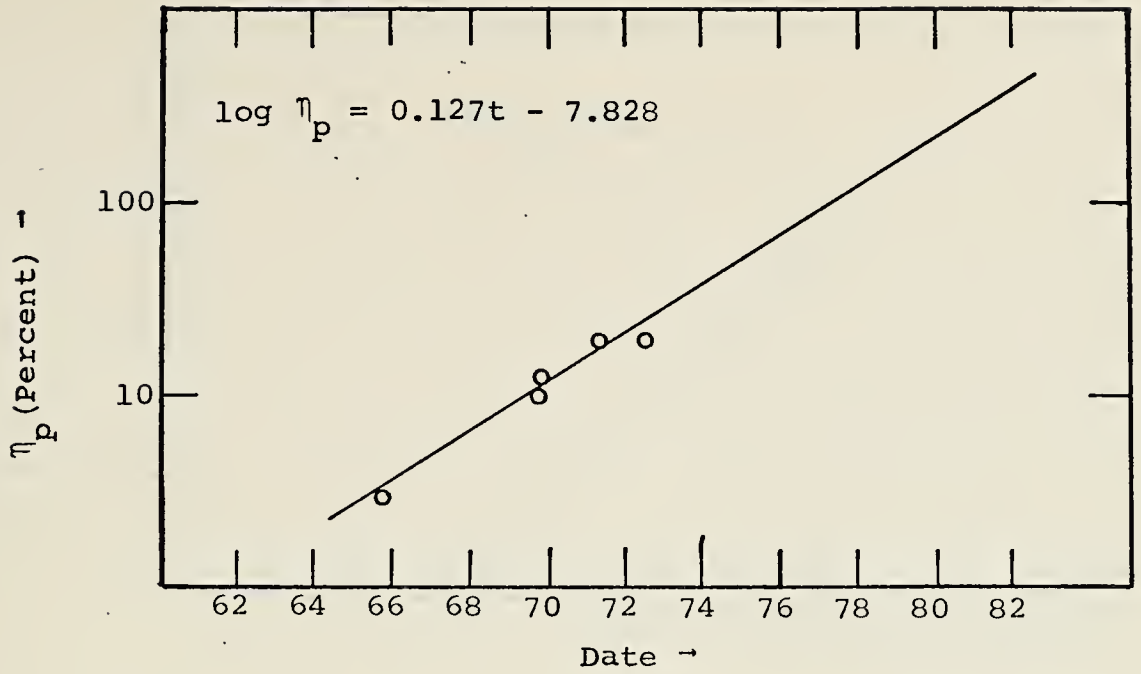
LCREP →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η_p (Percent) →
100
10
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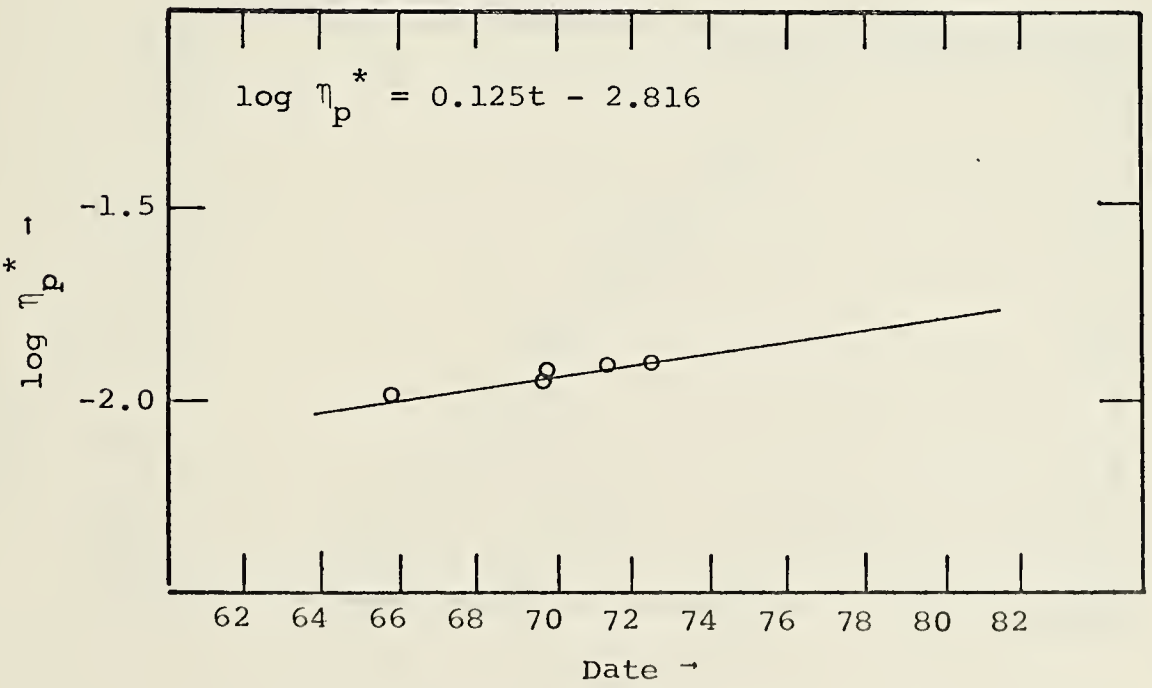
Date →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-2.0
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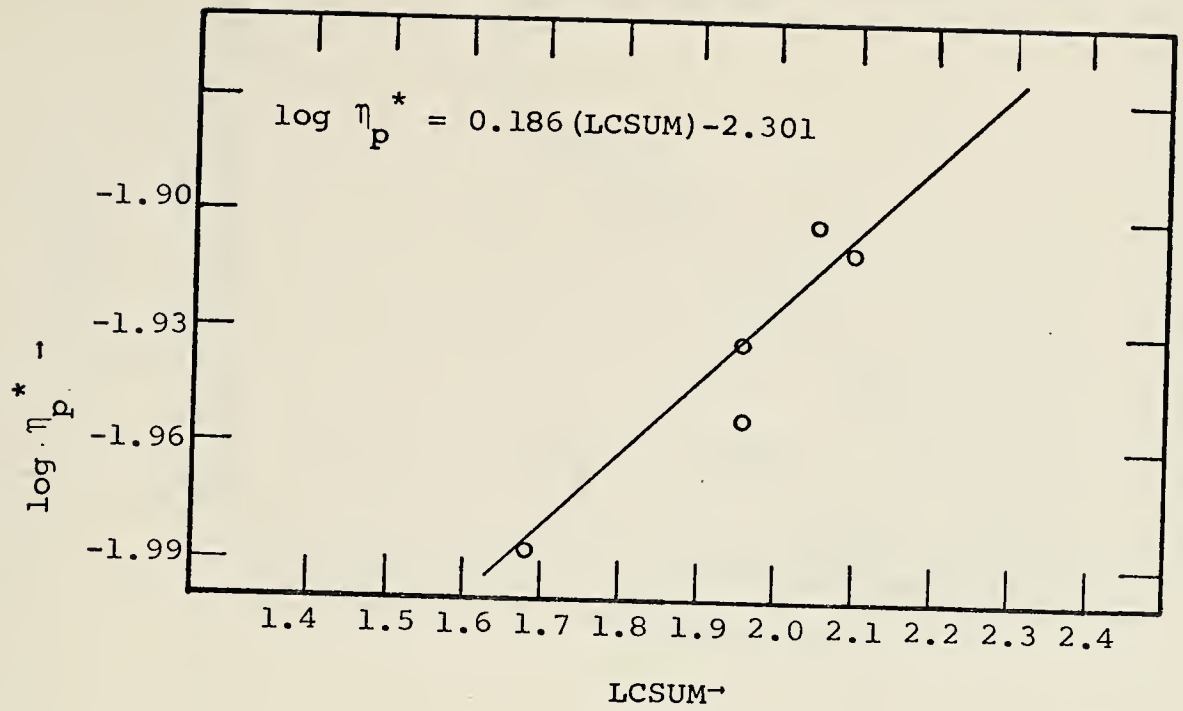
Date →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-1.93
-1.96
-1.99
log η_p^*
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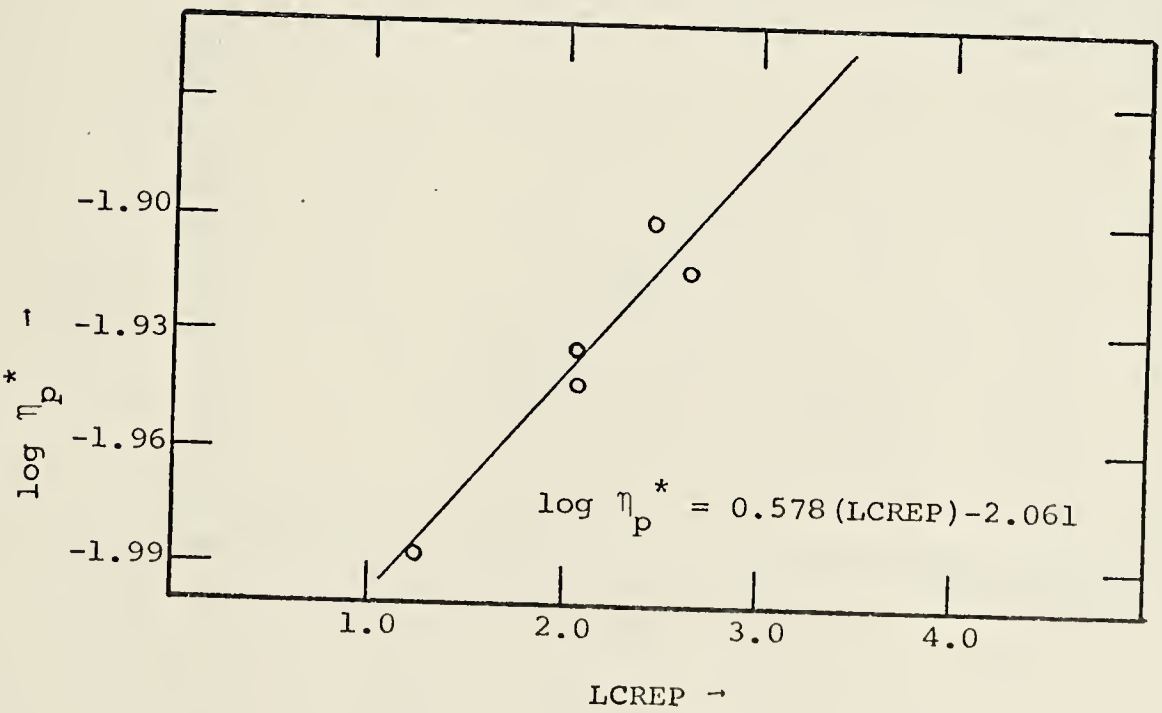
LCSUM→


-1.90
-1.93
-1.96
-1.99
log η_p^*
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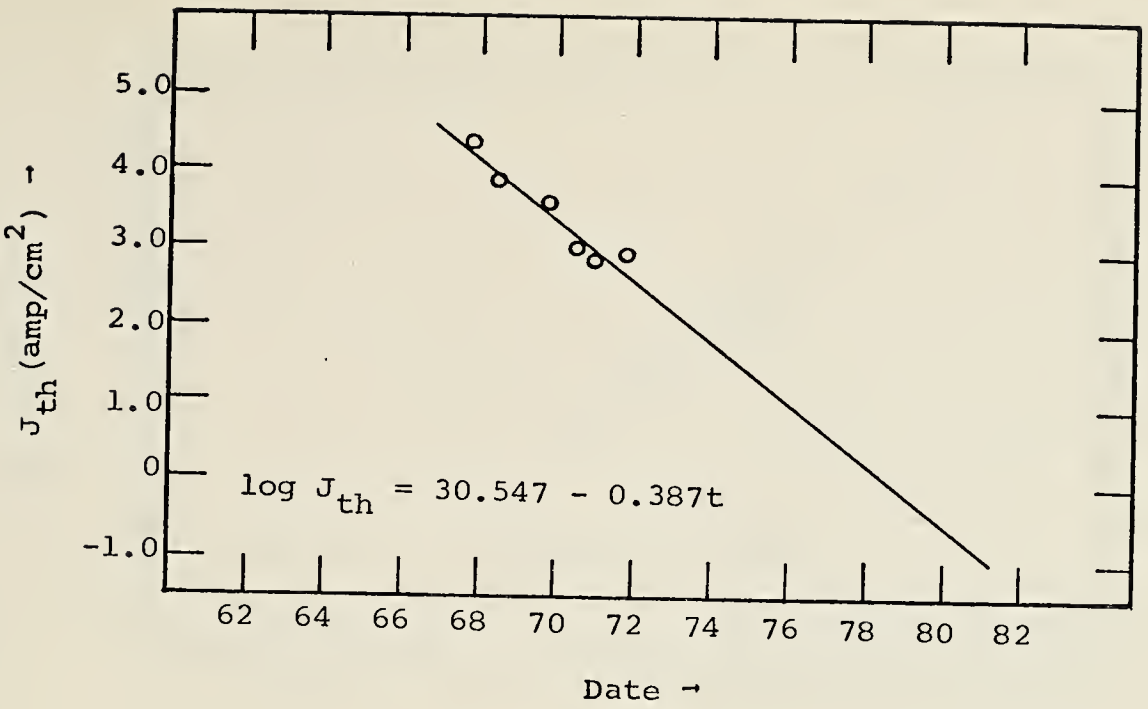
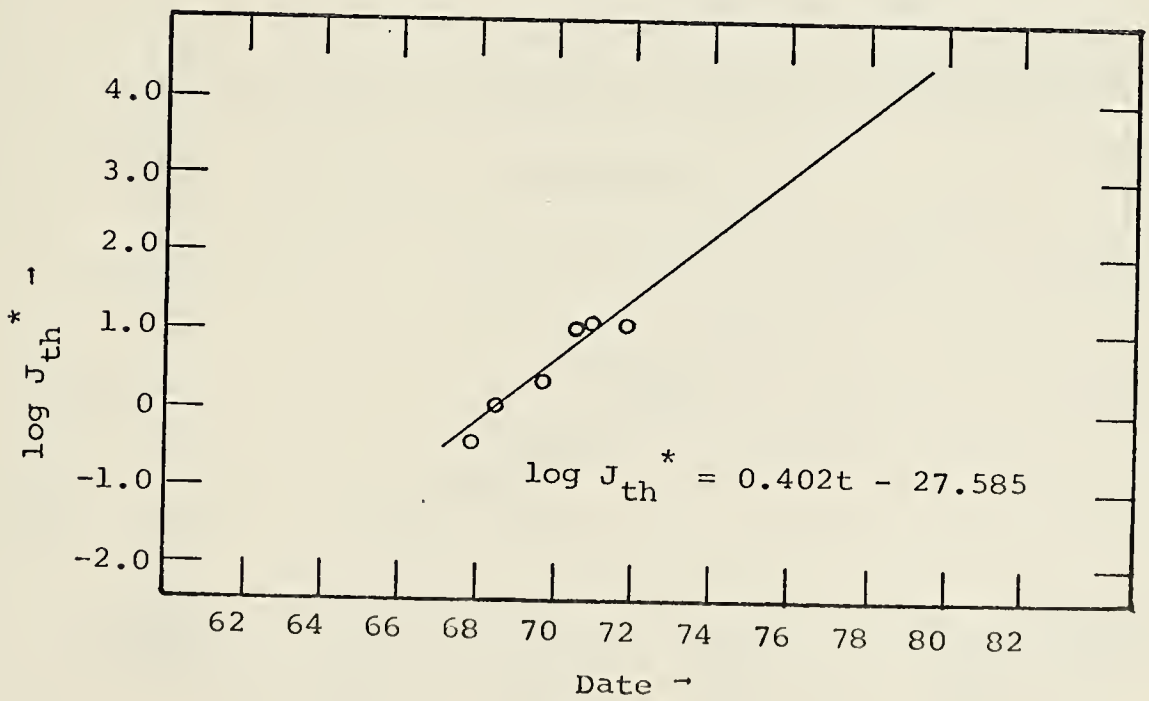
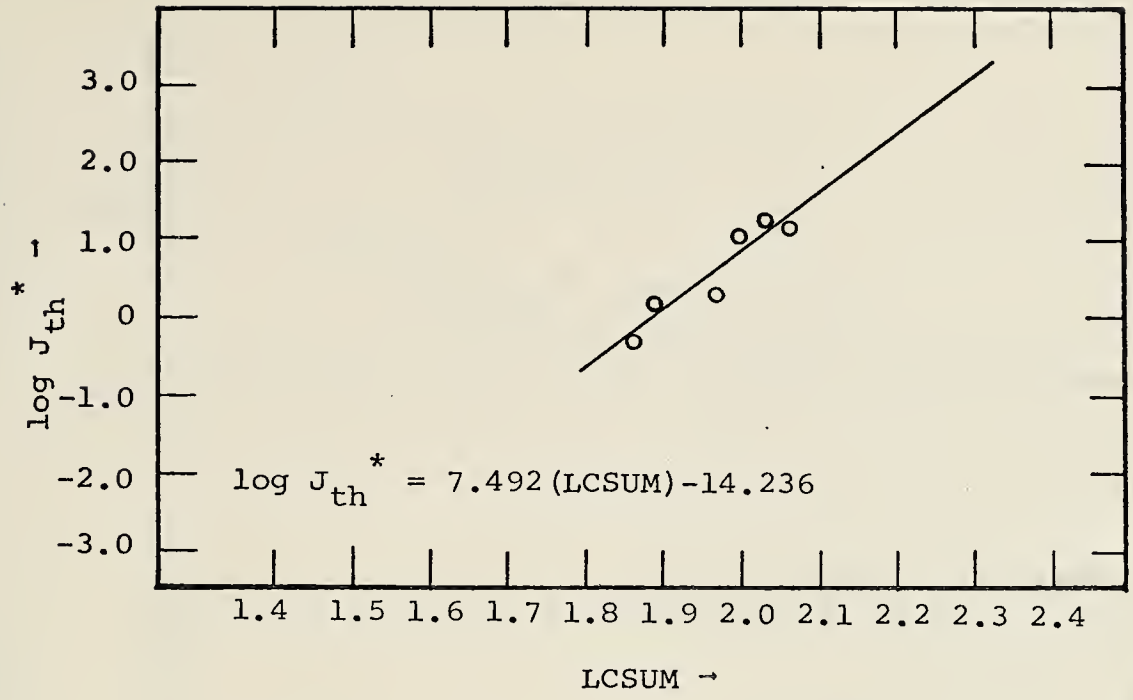
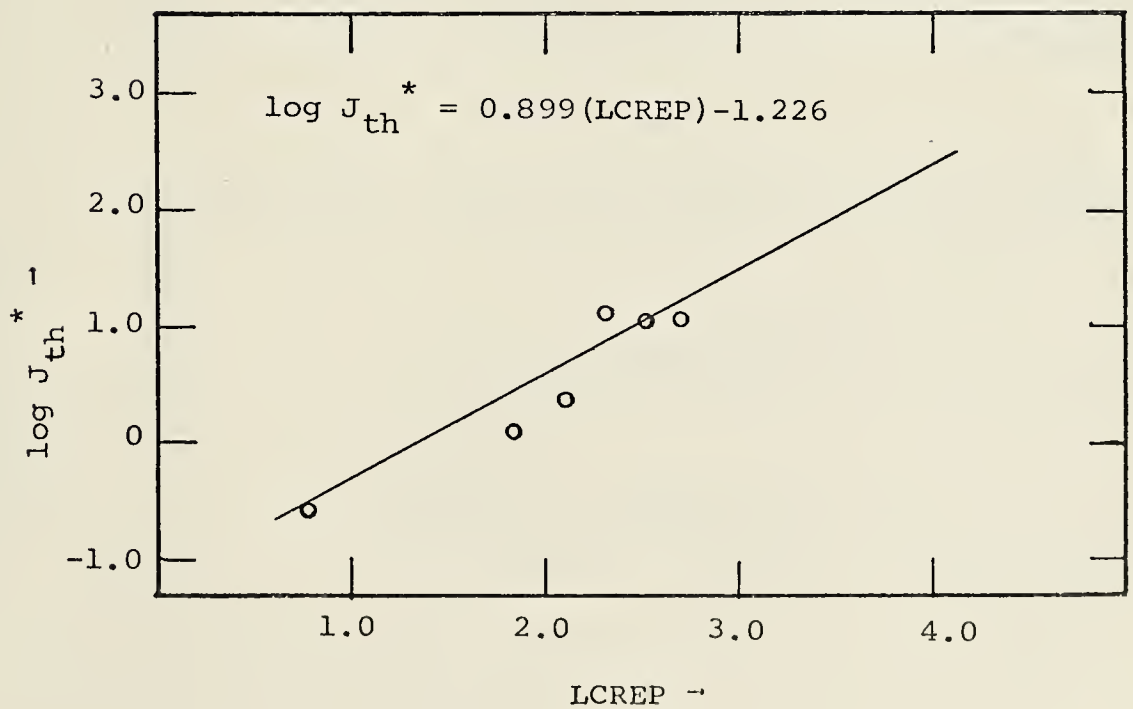
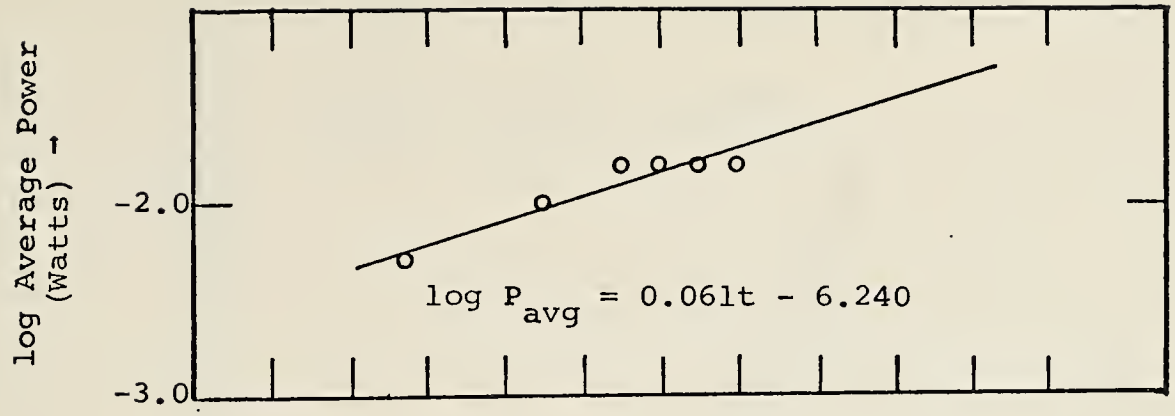
LCREP →

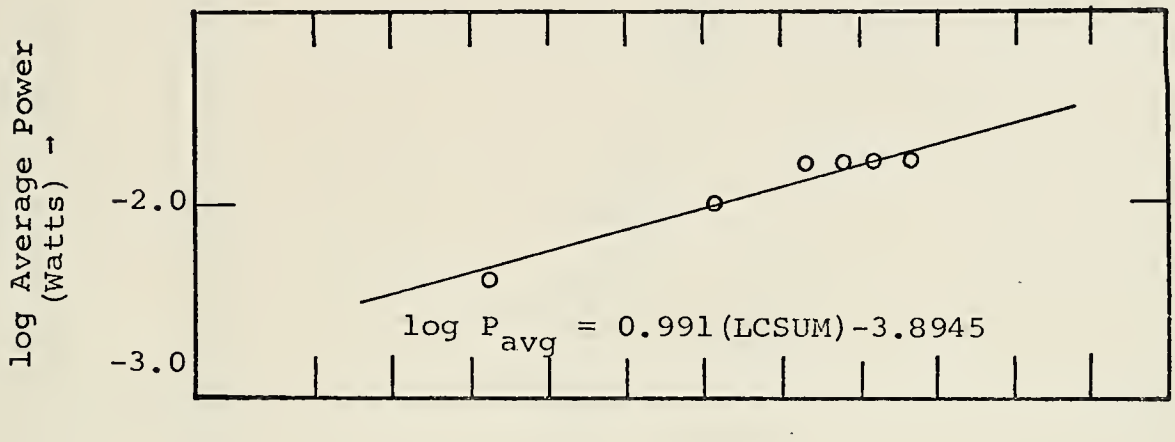

5.0
4.0
3.0
2.0
1.0
0
-1.0
J_{th} (amp/cm^2) →
log J_{th} = 30.547 - 0.387t
62 64 66 68 70 72 74 76 78 80 82
Date →

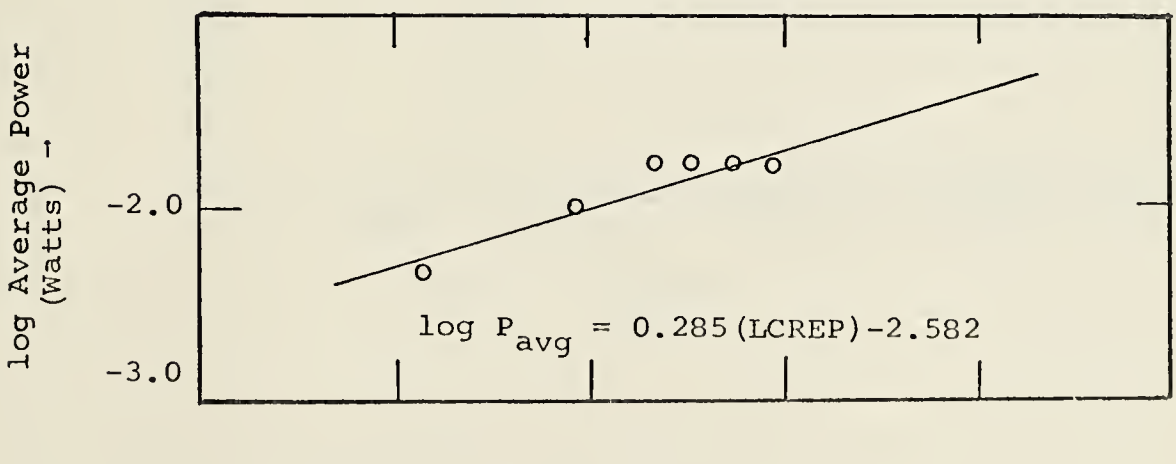

4.0
3.0
2.0
1.0
0
-1.0
-2.0
log J_{th}^* →
log J_{th}^* = 0.402t - 27.585
62 64 66 68 70 72 74 76 78 80 82
Date →

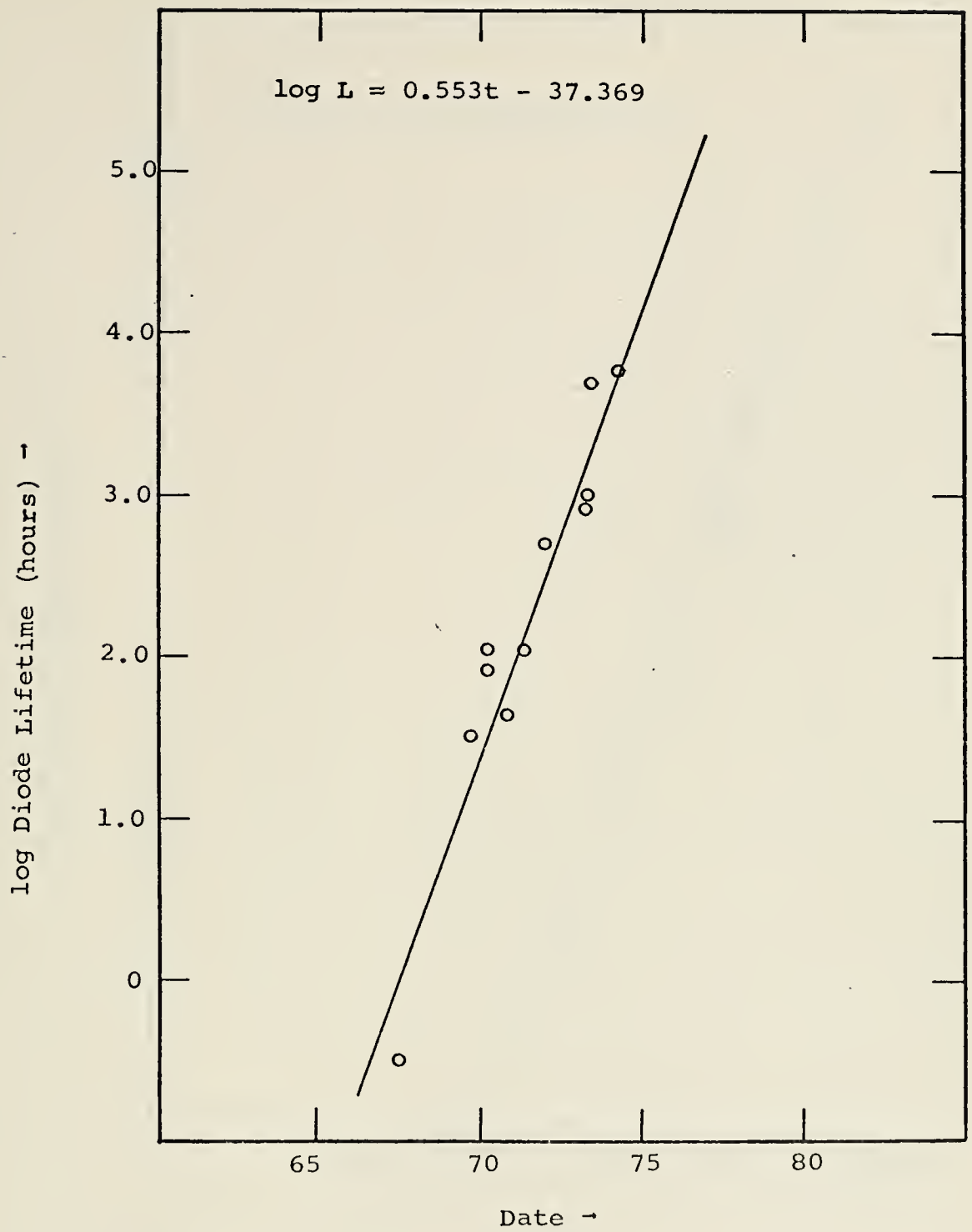

3.0
2.0
1.0
0
-1.0
-2.0
-3.0
log J_{th}^* ↑
log J_{th}^* = 7.492(LCSUM)-14.236
1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4
LCSUM →

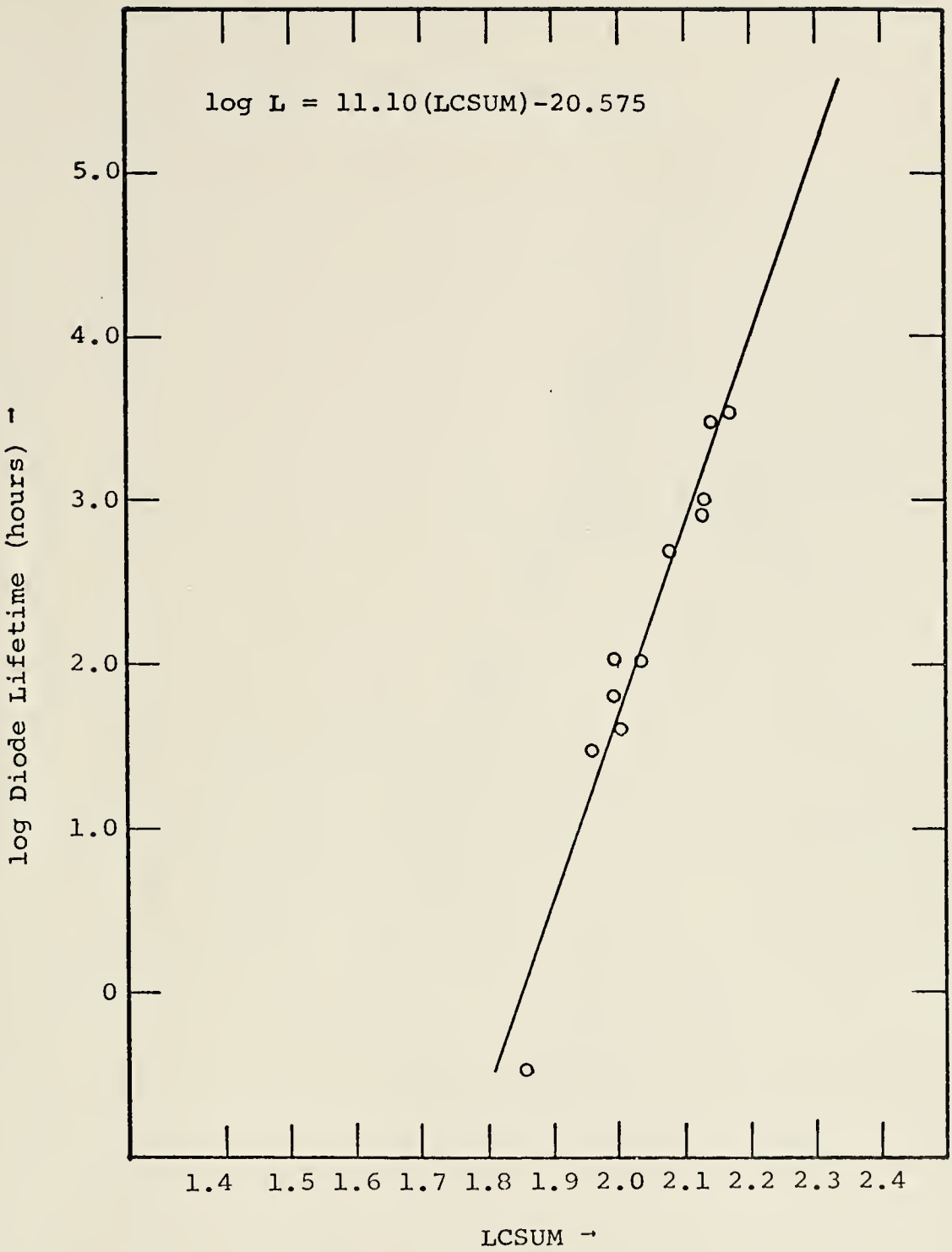

log J_{th}^* = 0.899(LCREP)-1.226
3.0
2.0
1.0
0
-1.0
log J_{th}^* ↑
1.0 2.0 3.0 4.0
LCREP →

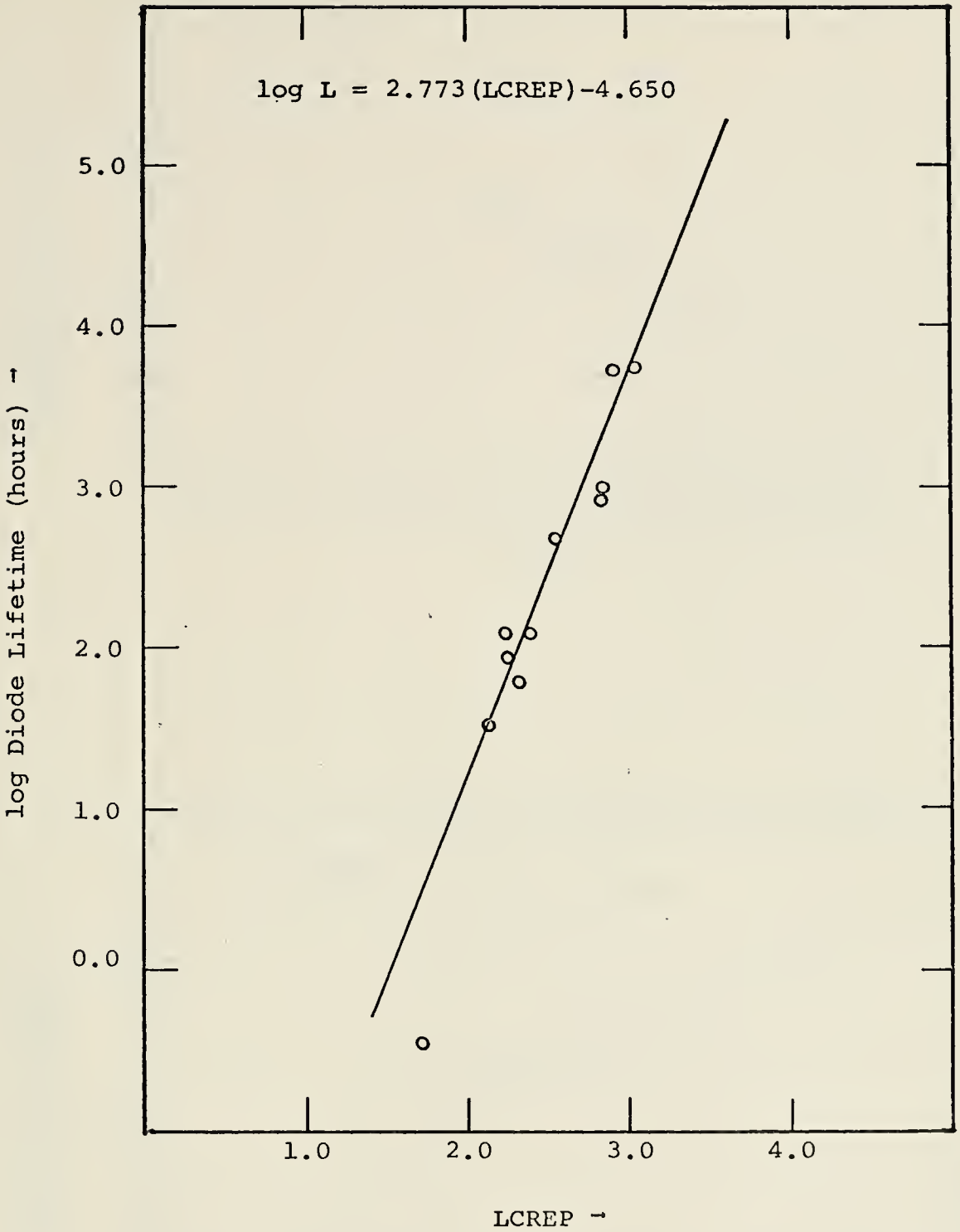

log Average Power
(Watts) →
-2.0
-3.0
log P_{avg} = 0.061t - 6.240

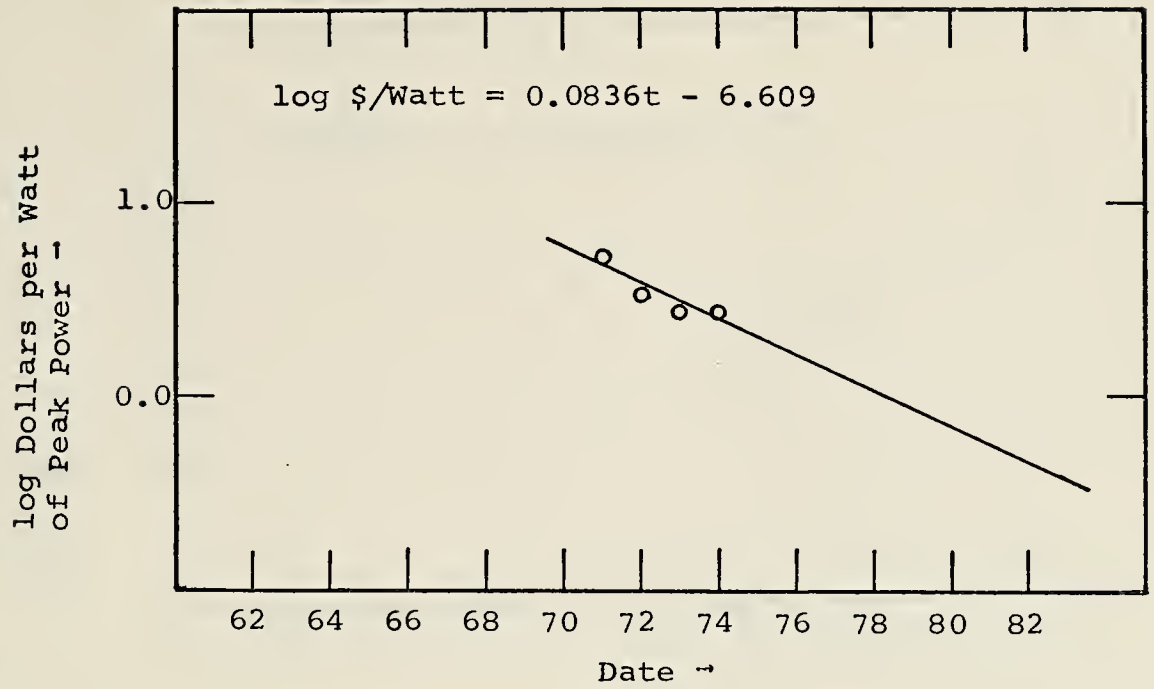

log Average Power
(Watts) →
-2.0
-3.0
log P_{avg} = 0.991(LCSUM)-3.8945

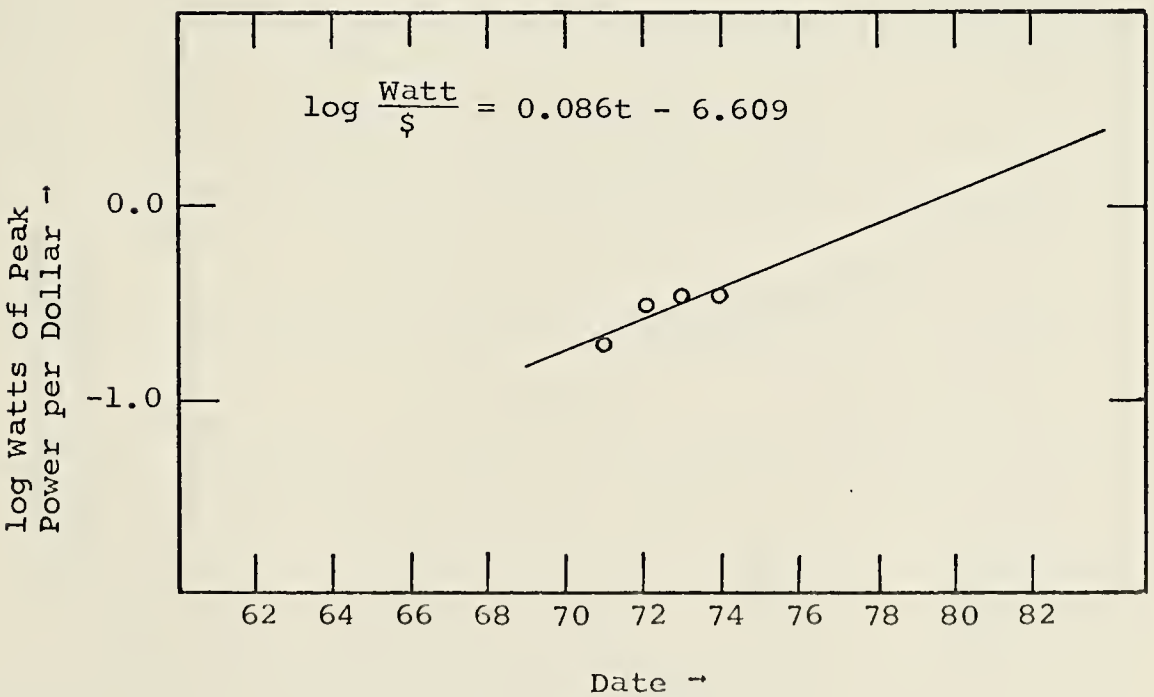

log Average Power
(Watts) →
-2.0
-3.0
log P_{avg} = 0.285(LCREP)-2.582

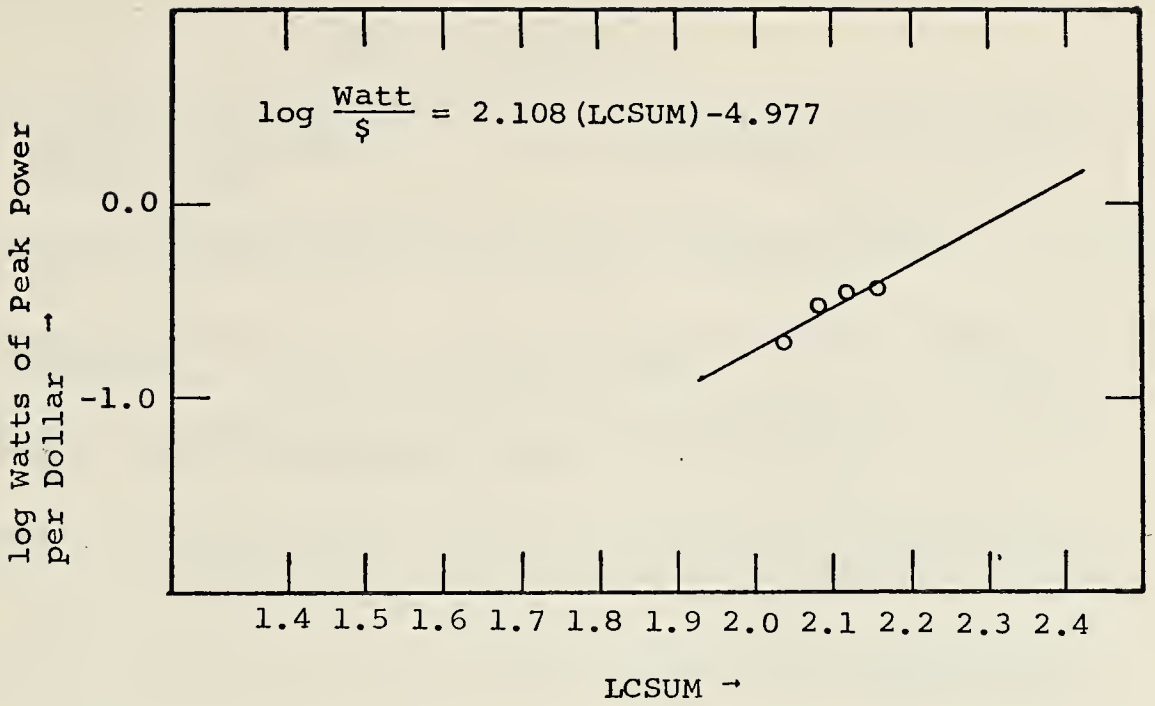

log L = 0.553t - 37.369
5.0
4.0
3.0
2.0
1.0
0
log Diode Lifetime (hours) →
65
70
75
80
Date →

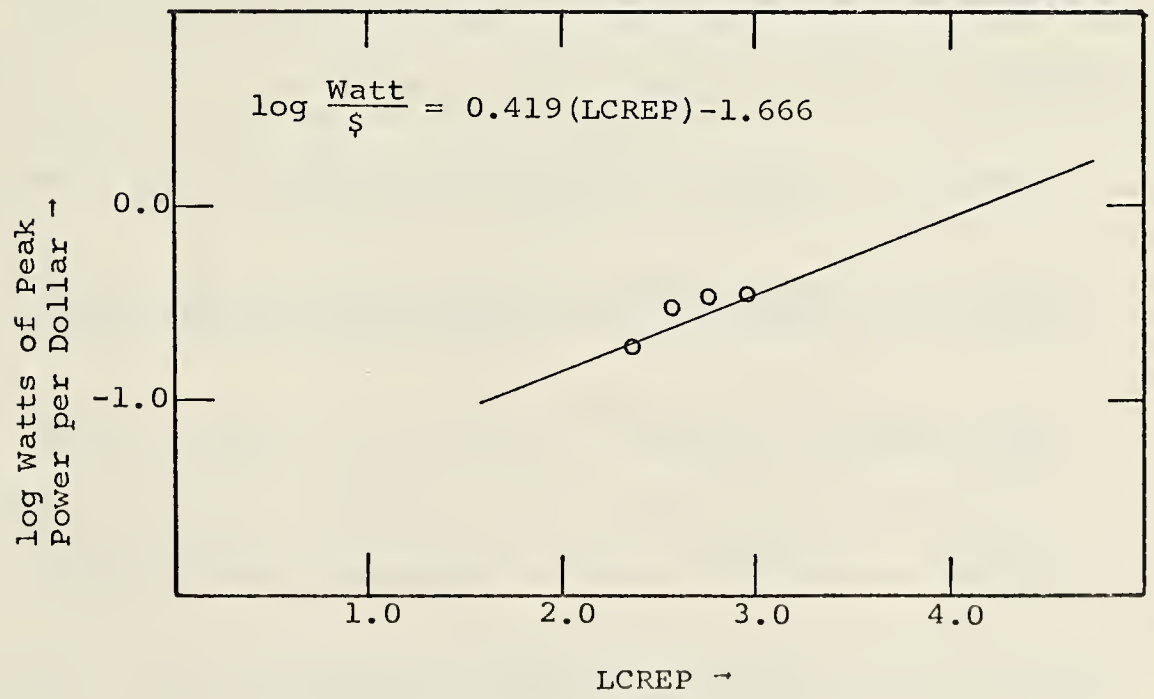

log L = 11.10(LCSUM)-20.575
log Diode Lifetime (hours) →
5.0
4.0
3.0
2.0
1.0
0
1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4
LCSUM →


log L = 2.773(LCREP)-4.650
5.0
4.0
3.0
2.0
1.0
0.0
log Diode Lifetime (hours) →
1.0
2.0
3.0
4.0
LCREP →


log $/Watt = 0.0836t - 6.609
log Dollars per Watt of Peak Power →
1.0
0.0
62 64 66 68 70 72 74 76 78 80 82
Date →


log Watt/$ = 0.086t - 6.609
log Watts of Peak Power per Dollar →
0.0
-1.0
62 64 66 68 70 72 74 76 78 80 82
Date →


log Watt/$ = 2.108(LCSUM)-4.977
log Watts of Peak Power per Dollar →
0.0
-1.0
1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4
LCSUM →


log Watt/$ = 0.419(LCREP)-1.666
log Watts of Peak Power per Dollar →
0.0
-1.0
1.0
2.0
3.0
4.0
LCREP →

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